THE ROLE OF FIRM FACTORS IN DEMAND, COST, AND EXPORT MARKET SELECTION FOR CHINESE FOOTWEAR PRODUCERS

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ABSTRACT

In this paper we use micro data on both trade and production for a sample of large Chinese manufacturing firms in the footwear industry from 2002-2006 to estimate an empirical model of export demand, pricing, and market participation by destination market. We use the model to construct indexes of firm-level demand, cost, and export market profitability. The empirical results indicate substantial firm heterogeneity in both the demand and cost dimensions with demand being more dispersed. The firm-specific demand and cost components are very useful in explaining differences in the extensive margin of trade, the length of time a firm exports to a destination, and the number and mix of destinations, as well as the export prices, while cost is more important in explaining the quantity of firm exports on the intensive margin. We use the estimates to analyze the reallocation resulting from removal of the quota on Chinese footwear exports to the EU and find that it led to a rapid restructuring of export supply sources in favor of firms with high demand and low cost indexes.

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Abstract

In this paper we use micro data on both trade and production for a sample of large Chinese manufacturing firms in the footwear industry from 2002-2006 to estimate an empirical model of export demand, pricing, and market participation by destination market. We use the model to construct indexes of firm-level demand, marginal cost, and fixed cost. The empirical results indicate substantial firm heterogeneity in all three dimension with demand being the most dispersed. The firm-specific demand and marginal cost components account for over 30 percent of market share variation, 40 percent of sales variation, and over 50 percent of price variation among exporters. The fixed cost index is the primary factor explaining differences in the pattern of destination markets across firms. The estimates are used to analyze the supply reallocation following the removal of the quota on Chinese footwear exports to the EU. This led to a rapid restructuring of export supply sources on both the intensive and extensive margins in favor of firms with high demand and low fixed costs indexes, with marginal cost differences not being important.

1 Introduction

Firm-level heterogeneity has become a driving factor in theoretical models and empirical studies that analyze firm pricing decisions, destination decisions, and trade patterns in international markets. Theoretical models that embody heterogeneous firms have been developed by Eaton and Kortum (2002), Melitz (2003), and Bernard, Eaton, Jensen, and Kortum (2003) and used to analyze aggregate patterns of trade.

There are multiple potential sources of firm heterogeneity that can generate differences across firms in their trade decisions. Building on models of industry dynamics by Jovanovic (1982) and Hopenhayn (1992), heterogeneity in production costs has been one, heavily-analyzed source of firm differences. In an empirical study using French firm-level data, Eaton, Kortum, and Kramarz (2011) find that accounting for firm heterogeneity in efficiency results in substantial improvements in the ability to predict which firms enter which destination markets and, to a lesser degree, the volume of sales in the destination. A second source of firm heterogeneity reflects differences in the fixed cost of entering new export markets. In addition to firm efficiency, Das, Roberts and Tybout (2007), Eaton, Kortum, and Kramarz (2011), and Arkolakis (2010) find that differences in entry costs are important in explaining patterns of dynamic export entry, or the number of markets a firm serves, or the size distribution of exporting firms. More recently, a third source of heterogeneity, reflecting differences in product quality or other demand-side factors that lead to differences in market shares across firms, has been incorporated in trade models. Johnson (2012) and Khandelwal (2010) estimate structural models of demand using product-level data on prices and trade flows between countries and find evidence consistent with quality variation at the country level.[1] Crozet, Head, and Mayer (2012) exploit firm level data on prices, exports, and direct quality measures for champagne producers and find quality is positively correlated with price, quantity and the number of destination markets the firm sells in. They also show that it is important to correct for the endogenous selection of destination markets when estimating the effect of quality on export variables.

In this paper we quantify the importance of three sources of firm heterogeneity, marginal production cost, export fixed cost, and demand, in explaining the export decisions of Chinese footwear manufacturing firms across seven destination markets. Our framework allows us to tie together the pricing, output, and participation decisions with a consistent set of firm-level demand and cost components. Based on their empirical study of French exporting firms, Eaton, Kortum, and Kramarz (2011) conclude that it is important to recognize that firm-level characteristics impact decisions in many markets and conclude that "any theory ignoring

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[1]Reduced form empirical studies by Hallak and Sivadasan (2009), Kugler and Verhoogen (2012), Manova and Zhang (2012), and Baldwin and Harrigan (2011) use firm-level export price data and conclude that quality variation is an important dimension of firm heterogeneity in traded goods.

features of the firm that are universal across markets misses much." We focus on these firm-level characteristics that are universal across the firm's markets.

The success of Chinese manufacturing exports is one of the most significant phenomena in world trade in the last two decades, however, debates remain about the underlying causes at the individual producer level. One possibility is that Chinese firms invested in "capability building" to improve their product appeal and demand (See Sutton (2007), Brandt, Rawski, and Sutton (2008) and Schott (2008)) while a second possibility is that they succeeded primarily because of low labor and input costs that allow them to serve as a manufacturing base for foreign-owned firms (Branstetter and Lardy (2008)). In this paper we study the relative importance of firm-level cost and demand factors in explaining Chinese firm-level export performance by developing a structural model of demand, cost, and dynamic export participation that can quantify firm heterogeneity in each of these dimensions.[2]

We estimate the model using micro data on prices and quantities of exported goods and firm costs for a panel of 738 large Chinese exporting firms in the footwear industry from $2002-2006$. In our data set, the firm-level export price, quantity, and destination patterns indicate a potentially important role for three dimensions of firm heterogeneity that persist across destinations. Firms that export to many destinations also export to more difficult destinations and have higher average export quantities in each destination. This is consistent with either persistent firm-level demand heterogeneity or heterogeneity in marginal cost. These same firms also have higher average export prices which suggests that the demand differences are costly to produce or maintain and is not consistent with low cost being the sole determinant of export success. Furthermore, conditional on the same average sales per destination, some Chinese firms sys-

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[2]Several other empirical papers allow for multiple dimensions of heterogeneity. Gervais (2015) uses U.S. manufacturing sector production data to estimate firm-level demand and productivity components and shows that these help to explain patterns of firm exporting. Eslava, Haltiwanger, Kugler, and Kugler (2004) use plant-level input and output prices for Colombian manufacturing plants to estimate demand curves and production functions at the plant level and then analyze patterns in the residuals and how they are related to reallocations of activity across firms in response to economic reforms. Aw and Lee (2014) find that both firm-level demand and productivity components are important in explaining the decision of Taiwanese firms to enter a foreign market with the relative performance of the two factors depending on the destination market and whether it enters by exporting or through FDI. Hottman, Redding, and Weinstein (2014) use price and quantity data for highly-disaggregated consumer goods to estimate a structural model of product demand and pricing. They find that differences in quality account for 50 to 70 percent of the variance in firm size, while product scope accounts for 20 to 30 percent, and cost differences for less than 24 percent. Heterogeneity in demand characteristics is the dominant source of firm size variation.

tematically export to more markets, implying lower firm-level export fixed cost. The only way to distinguish the role of cost and demand heterogeneity is to specify a structural model that includes distinct demand, marginal cost and fixed cost components at the firm level.

In the econometric model we develop, the measure of firm demand heterogeneity relies on across-firm differences in export market shares, controlling for firm prices, in the destination markets. The measure of cost heterogeneity relies on differences in firm export prices, controlling for observable firm costs and markups, across destinations. Fixed cost heterogeneity relies on differences in market participation patterns, controlling for cost and demand differences. All three factors play a role in determining the firm's profits in each export market and thus the decision to export. We exploit the fact that, in the export context, we have multiple observations on many of the firms because they export to multiple destination markets and this helps to both identify the distribution of firm-level demand and cost components and control for the endogenous selection of which markets to sell in. The econometric methodology we utilize is a practical application of a Hierarchical Bayesian method that relies on MCMC and Gibb's sampling for implementation. This allows us to both include a large number of unobservables, three for each of our 738 firms, and to incorporate them in nonlinear equations, such as the probability of exporting, in a very tractable way.

The empirical results indicate that across-firm differences in the number and mix of export destinations is substantially affected by heterogeneity in the fixed cost dimension. Demand heterogeneity also has a small impact on differences in the extensive margin of exports. On the intensive margin, both the demand and marginal cost factors are approximately equally important in explaining export price variation across firms and destinations, but demand differences are more important in explaining variation in export revenue. Finally, we use our firm indexes to study the reallocation of export sales across Chinese producers in response to the removal of the quota on Chinese exports of footwear to the EU. We find that removal of the quota led to a substantial change in the mix of firms that exported to the EU with the shift in composition toward firms with higher demand and lower fixed cost indexes, but no strong correlation with marginal cost differences.

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The next section of the paper develops the theoretical model of export demand, pricing, and market participation. The third section develops the estimation methodology, the fourth section describes the Chinese firm-level data and summary statistics. The fifth section presents the structural parameter estimates and the final section analyzes the changes in the composition of exporting firms in response to removal of the EU quota on Chinese footwear imports.

2 Theoretical Model of a Firm's Export Revenue

2.1 Demand

We begin with a demand model that can be used to estimate an index of firm demand. Denote k as an individual 6-digit product produced by a specific firm f. A firm can produce and export multiple products. An individual importer's utility function from purchasing product k from firm f is :

$$U_{kf}^{dt} = \delta_{kf}^{dt} + \epsilon. \tag{1}$$

This specification allows for a variety-specific component δ_{kf}^{dt} that varies by destination market and year and a transitory component ϵ that captures all heterogeneity in preferences across importers.[3] Berry (1994) shows that, if ϵ is assumed to be a Type I extreme value random variable then we can aggregate over importers and express the market share for product kf in market dt. Define the inclusive value of all varieties in the market as $V^{dt} = \sum_{kf} \exp(\delta_{kf}^{dt})$. The market share for product kf in market dt can be written in the logit form $\tilde{s}_{kf}^{dt} = \exp(\delta_{kf}^{dt})/V^{dt}$. If we normalize this market share by a single variety where $\delta_0^{dt} = 0$ the normalized logarithmic market share takes the simple form:

$$ln(\tilde{s}_{kf}^{dt}) - ln(s_0^{dt}) = \delta_{kf}^{dt}. \tag{2}$$

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[3]We think of the consumers in the destination market as wholesalers, retailers, or trading companies that buy from the Chinese producers and resell to households. The wholesalers demand for Chinese exports will depend on the household demand in their own country but, since we do not have household-level data, we do not attempt to model this household demand. Instead, we capture all the effects of consumer income, tastes, competing suppliers in the destination and market power in the wholesale/retail sector in the modelling of the destination-specific utility component δ_{kf}^{dt}.

We will model the variety-specific term δ_{kf}^{dt} as a combination of firm, product group, destination market, and variety components. Specifically, if product k is produced by firm f, then

$$\delta_{kf}^{dt} = \xi_f + \xi_k - \alpha_d \ln \tilde{p}_{kf}^{dt} + u_{kf}^{dt} \tag{3}$$

This equation says that there is a firm component ξ_f or "brand-name" effect to the utility derived from this product. This brand-name effect will be unique to each firm and constant across all markets in which it operates and over time. It could reflect differences in the stock of customers that are familiar with firm f, size of its distribution network, or quality of the firm's product. Holding price fixed, an increase in ξ_f will raise the market share for this variety in all markets. Since the ξ_f captures all firm-level factors that systematically affect the utility that importers receive from this product, we will refer to it as a **firm demand component.**[4] There is also a product group utility shifter ξ_k that will lead to higher utility for some product groups in all markets, holding price fixed. The utility and market share of the variety will be declining in the price of the variety where $\tilde{p}_{kf}^{dt}$ is the price paid by the importers for product kf in the destination market. To convert this price into the FOB price, p_{kf}^{dt}, set by the producing firm, we incorporate ad valorem trade costs between China and each destination market $\ln \tilde{p}_{kf}^{dt} = \ln p_{kf}^{dt} + \ln(1 + \tilde{\tau}_{dt})$. In this case $\tilde{\tau}_{dt}$ captures all exchange rate effects, tariffs, and shipping costs between China and each destination market in each year. The final term u_{kf}^{dt} captures market level shocks to the demand for product kf. Substituting equation (3) and destination-specific price into the normalized market share equation gives the demand equation for product kf:

$$ln(s_{kf}^{dt}) \equiv ln(\tilde{s}_{kf}^{dt}) - ln(s_0^{dt}) = \xi_f + \xi_k - \alpha_d \ln p_{kf}^{dt} + \tau_{dt} + u_{kf}^{dt} \tag{4}$$

where $\tau_{dt} = -\alpha_d ln(1 + \tilde{\tau}_{dt})$. The parameter α_d, which captures the market share response to a change in the FOB price, is allowed to vary across destination markets to reflect the country-specific differences in the consumer tastes, income, and the structure of the domestic retail sector.

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[4]The demand model we use relies on horizontal differentiation across varieties and is not one where firm's products can be ranked by quality. For this reason, we do not refer to ξ_f as an index of firm "quality" but rather use the broader term "firm demand component" because it will capture any factor that generates larger market shares for the firm's varieties, holding price fixed.

This demand equation can be estimated using data on the market shares of varieties in different destination markets. Overall, the demand model contains a destination-specific price parameter α_d, destination market/year effects τ_{dt}, product group effects ξ_k, and a firm-specific demand shifter ξ_f. One goal of the empirical model developed below will be to estimate the parameters of equation (4) including the firm-specific demand factor ξ_f.

2.2 Cost and Pricing

To incorporate heterogeneity arising from the production side of the firm's activities we model log marginal cost of product kf in market dt as:

$$\ln c_{kf}^{dt} = \tilde{\gamma}_{dt} + \gamma_k + \gamma_w lnw_f^t + h(\xi_f) + \omega_f + v_{kf}^{dt} \tag{5}$$

where $\tilde{\gamma}_{dt}$ and γ_k are destination/year and product-group cost factors, and w_f^t is a set of observable firm-specific variable input prices and fixed factors. The specification includes two additional sources of firm-level unobservables. The function $h(\xi_f)$ is included to control for the fact that firms that have higher demand or more desirable products will likely have higher costs if the extra demand is the result of higher quality or investments to build a customer base. The second firm-level unobservable ω_f is included to capture time-invariant differences in marginal cost across producers. Finally v_{kf}^{dt} are cost shocks at the product-firm level and the firm is assumed to observe these prior to setting the price. For estimation purposes we will combine the firm costs resulting from ξ_f and ω_f into a single **firm marginal cost component** that we will represent as $c_f = h(\xi_f) + \omega_f$.

Assuming monopolistically competitive markets, a profit-maximizing firm facing the demand curve in equation (4) will charge a price for product kf in market dt given by:[5]

$$\ln p_{kf}^{dt} = \gamma_{dt} + \gamma_k + \gamma_w lnw_f^t + c_f + v_{kf}^{dt} \tag{6}$$

where $\gamma_{dt} = \ln(\frac{\alpha_d}{\alpha_d-1}) + \tilde{\gamma}_{dt}$. This pricing equation shows that the price of product kf in market dt will depend on the destination-specific demand parameter α_d and all the marginal

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[5]If we assume firms compete by taking into account the impact of their prices on the inclusive value V^{dt}, then the markup term becomes $ln(\frac{\alpha_d(1-s_i^{dt})}{\alpha_d(1-s_i^{dt})-1})$. Because virtually all of our exporting firms have small market shares (as described in the data section), we ignore the effect of the firm's price on the inclusive value.

cost determinants in equation (5). In particular, this pricing equation shows that c_f will be a firm-level component of the export price. A second goal of our empirical model is to estimate the parameters of the pricing equation (6) including the firm cost component c_f while allowing for an unconstrained correlation between c_f and ξ_f.

2.3 Export Revenue and Profitability

Using the demand and pricing equations, (4) and (6), we can express the expected revenue of product kf in market dt. Define the destination specific markup as $\mu_d = \frac{\alpha_d}{\alpha_d - 1}$ and the aggregate demand shifter in market dt as M^{dt}/V^{dt} where M^{dt} is the total market size. Using these definitions we can express the logarithm of the expected revenue for product kf as the sum of three components, one of which depends only on market-level parameters and variables, one which incorporates all product-group variables, and one which incorporates all firm-level variables:

$$\ln r_{kf}^{dt} = \ln \Omega^{dt} + \ln r_k^d + \ln r^{dt}(\xi_f, c_f) \tag{7}$$

where

$$\begin{aligned}
\ln \Omega^{dt} &= \ln(M^{dt}/V^{dt}) + \tau_{dt} + (1 - \alpha_d)(\ln \mu_d + \gamma_{dt}) \tag{8} \\
\ln r_k^d &= \xi_k + (1 - \alpha_d)\gamma_k \\
\ln r^{dt}(\xi_f, c_f) &= \xi_f + (1 - \alpha_d)\left(\gamma_w lnw_f^t + c_f\right) + C_{uv}
\end{aligned}$$

In this equation $\ln\Omega^{dt}$ captures all market-level factors that affect product revenue, including the market size and overall competition, tariff, exchange rate effects, markup, and destination-specific cost. The second term $\ln r_k^d$ captures all product group effects in both demand and cost.

The final term, $\ln r^{dt}(\xi_f, c_f)$, combines all the firm-specific factors that affect the export revenue of product kf in the market: the firm demand component ξ_f, the firm cost component c_f, and the observable firm-level marginal cost shifters $\gamma_w lnw_f^t$. The expectation over the variety-specific demand and cost shocks u_{kf}^{dt} and v_{kf}^{dt} is denoted by $C_{uv} = \ln E_{u,v}[exp(u_{kf}^{dt} + (1-\alpha_d)v_{kf}^{dt})]$. A larger value of ξ_f, reflecting higher demand for the firm's variety, will imply a larger value of $\ln r^{dt}(\xi_f, c_f)$. Since the term $(1 - \alpha_d)$ is negative, a higher value of c_f will imply a lower level

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of export revenue for the firm in this destination market. If variation in c_f across firms only reflects productivity differences, then high c_f would imply lower export revenue. However, as explained above, c_f can also include the cost of producing higher demand, so in this case $corr(c_f, \xi_f) > 0$ and thus, as we compare across firms, higher-demand firms will have higher export revenue if their larger market share, due to ξ_f, outweighs the increase in cost captured by c_f. Finally, the firm export revenue will vary by destination market because the marginal cost terms are scaled by $(1 - \alpha_d)$ and α_d is destination specific. In a destination with more elastic demand (larger α_d), the cost differences across firms are more important as a source of export revenue differences.

Given the functional form assumptions on demand and marginal cost, we can use the revenue equation for product kf, (7), to express the total expected profits that firm f will earn in market dt. If the firm sells a set of varieties, or product line, denoted by K_f, its profit in destination market dt is the sum of revenues over all its varieties scaled by the demand elasticity or, if expressed in logs:

$$\ln \pi^{dt}(\xi_f, c_f; w_f^t, K_f) = \ln \left[\frac{1}{\alpha_d} \right] + \ln \Omega^{dt} + \ln \left[\sum_{k \in K_f} r_k^d \right] + \ln r^{dt}(\xi_f, c_f). \qquad (9)$$

As shown by this equation, the firm component of export revenue enters directly into the firm's profits in the market and will be a useful summary statistic of the role of firm demand and cost factors in generating differences in the profitability of exporting firms in a destination market. For this reason we will refer to $\ln r^{dt}(\xi_f, c_f)$ as the **firm profit component.**[6]

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[6]Several other papers have characterized a firm's market participation decision when firm heterogeneity arises from both demand and cost factors. In a model in which firms produce differentiated goods and consumers value variety, Foster, Haltiwanger, and Syverson (2008) develop a "firm profitability index" that is the difference between a firm's demand shifter and its marginal cost. They show that this is correlated with patterns of firm survival. Katayama, Lu, and Tybout (2009) use firm-level revenue and cost data to estimate indexes of marginal cost and product appeal which they relate to consumer and producer surplus. Sutton (2007) introduces a measure of firm capability, defined as the pair of firm quality and labor productivity, which is similar to our $\ln r^{dt}(\xi_f, c_f)$. In his framework the two arguments of firm capability are not isomorphic because there is a lower threshold on firm quality which a firm must exceed to be viable. In our setting the two terms contribute differently to firm profit and participation across destination markets because the cost component is weighted by the demand elasticity in the destination market.

2.4 Exporting Decision

This model of demand, cost, and profits also implies a set of destination countries for each firm's exports. The firm's decision to export to market dt is based on a comparison of the profits earned by supplying the market with the costs of operating in the market. If firm f sells in market d in the current year t we assume that it needs to incur a fixed cost $\mu_f + \varepsilon_f^{dt}$ where μ_f is a firm-specific fixed cost and ε_f^{dt} is a destination fixed cost shock that is modeled as an independent draw from a $N(0,1)$ across all markets and years. By specifying the fixed cost in this way, we are allowing a third source of firm heterogeneity, in addition to ξ_f and c_f. We will refer to μ_f as the **firm fixed cost component.** If the firm has not sold in the market in the previous year, then it must also pay a constant entry cost κ_s. Define I_f^{dt-1} as the discrete export indicator that equals one if the firm exported to market d in year $t-1$ and zero if it did not. The firm will choose to export to this market if the current plus expected future payoff is greater than the fixed cost it must pay to operate.

To describe each firm's export participation decision, we summarize their individual state variables into $s_f^t = \{\xi_f, c_f, \mu_f, K_f, w_f^t\}$ and previous export status I_f^{dt-1}. The input price w_f^t and aggregate state variables Ω^{dt} are assumed to evolve exogenously and the firm has rational expectation of future values. We define the value function of the firm that is making the choice to export to a particular destination dt is:

$$V^{dt}(s_f^t, \Omega^{dt}, I_f^{dt-1}, \varepsilon_f^{dt}) = \max_{I_f^{dt} \epsilon (0,1)} \left[\pi^{dt}(s_f^t, \Omega^{dt}) - (1 - I_f^{dt-1})\kappa_s - (\mu_f + \varepsilon_f^{dt}) + V_e^{dt}(s_f^t, \Omega^{dt}), V_n^{dt}(s_f^t, \Omega^{dt}) \right]$$

(10)

The first term in brackets is the payoff to exporting, which is the sum of the current profit, net of the fixed and startup costs, plus the expected future value of they choose to export $V_e^{dt}(s_f, \Omega^{dt})$. The second term in brackets is the expected future payoff if they choose not to export in period t, $V_n^{dt}(s_f, \Omega^{dt})$. These expected future values are defined as:

$$V_e^{dt}(s_f^t, \Omega^{dt}) = \beta E_{\varepsilon_f', s_f', \Omega'} V^{dt+1}(s_f', \Omega' | I_f^{dt} = 1, s_f^t, \Omega^{dt})$$

$$V_n^{dt}(s_f^t, \Omega^{dt}) = \beta E_{\varepsilon_f', s_f', \Omega'} V^{dt+1}(s_f', \Omega' | I_f^{dt} = 0, s_f^t, \Omega^{dt})$$

Since the fixed cost contains the stochastic component ε_f^{dt} we can define the probability that the firm exports to a particular market as the probability that this component is less than the

net benefits of exporting. Define the latent export payoff variable as the difference in the two choices in equation (10):

$$Y_f^{dt} = \pi^{dt}(s_f^t, \Omega^{dt}) - (1 - I_f^{dt-1})\kappa_s - \mu_f + V_e^{dt}(s_f^t, \Omega^{dt}) - V_n^{dt}(s_f^t, \Omega^{dt}) \tag{11}$$

The discrete export participation variable is defined as:

$$I_f^{dt} = 1 \text{ if } Y_f^{dt} \geq \varepsilon_f^{dt} \tag{12}$$
$$= 0 \text{ otherwise}$$

The third goal of our empirical model is to estimate the firm's market participation decision. In our model it is a function of the firm factors ξ_f, c_f and μ_f, the observable marginal cost shifters w_f^t, the firm's product mix K_f, the aggregate desirability of the product in this destination Ω^{dt}, and the firm's prior period export experience I_f^{dt-1}. Define the vector of these variables $X_f^{dt} = (\xi_f, c_f, \mu_f, w_f^t, K_f, \Omega^{dt}, I_f^{dt-1})$ and assume that the latent variable Y_f^{dt} is approximated by a linear function of them, $Y_f^{dt} = X_f^{dt}\psi$ where ψ is the parameter vector to be estimated. Since the random component of the fixed cost ε_f^{dt} is normally distributed, this leads to a probit approximation to the policy function for the firm's export participation decision:

$$P(I_f^{dt}|X_f^{dt}) = \Phi(X_f^{dt}\psi) \tag{13}$$

where Φ is the normal cdf.[7]

Overall, the model developed in this section provides a unified framework for explaining a combination of continuous (firm-level sales, pricing) and discrete (market participation) decisions for Chinese exporting firms for a set of destination countries. It recognizes three sources of unobserved firm heterogeneity, in the form of correlated firm-level demand, marginal production cost, and fixed costs, that link the firm data on the endogenous set of export destination markets and the export prices and sales in each market chosen. We are interested in estimating the empirical distribution of these effects. The model can be estimated with firm-level data

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[7] Das, Roberts, and Tybout (2007), and Aw, Roberts, and Xu (2011) have estimated structural models of the firm's discrete export decision. They calculate the long-run firm values V_e and V_n and estimate the distribution of fixed costs and entry costs. Using the insights of Hotz and Miller (1993), it is possible to invert the choice probabilities in equation 13 and retrieve the value functions. We do not pursue this avenue in this paper because we do not have any need for these objects and equation 13 is sufficient for our goal of estimating the distributions of ξ_f and c_f.

on export prices, quantities, production costs, and destination markets.[8] It will allow us to infer the three unobserved firm-level components and combine them into a natural index of the firm's ability to generate export market profits. In the next section we discuss the econometric methods that we use to estimate the model.

3 Estimation

Before we move to the details of estimation of the three structural equations, demand (4), pricing (6), and export market participation (13), we summarize the data we observe. For each firm, we observe a sequence of cost shifters lnw_f^t and export market participation dummies I_f^{dt}. Conditional on $I_f^{dt} = 1$, we also observe prices lnp_{fk}^{dt} and market shares $\ln s_{fk}^{dt}$ for each product sold by firm f. We denote the full set of data for firm f (across all destinations, products, and years) as D_f and the full set of data over all firms as D.

In the demand equation we estimate destination-specific parameters α_d and destination-year trade barriers τ_{dt}. Using the pricing equation we recover how prices depend on firm-level wage rates with the parameter γ_w, destination-specific cost differences γ_d, and product group cost differences γ_k. The final specification issue for the demand and pricing equation concerns the shocks u_{kf}^{dt} and v_{kf}^{dt}. We allow them to be both serially and contemporaneously correlated.

$$
\begin{aligned}
u_{kf}^{dt} &= \rho^u u_{kf}^{dt-1} + eu_{kf}^{dt} \\
v_{kf}^{dt} &= \rho^v v_{kf}^{dt-1} + ev_{kf}^{dt}
\end{aligned}
\tag{14}
$$

where the two transitory shocks, eu and ev are distributed:

$$
e = (eu, ev) \sim N(0, \Sigma_e).
$$

In the demand and pricing equations we allow for multiple sources of serial correlation through the firm effects ξ_f and c_f and the serially-correlated transitory shocks u_{kf}^{dt} and v_{kf}^{dt}.

The export participation equation in each market (13) depends on all three sources of firm-level heterogeneity. Since they are assumed to enter the latent payoff Y_f^{dt} linearly, we combine

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[8]If we used only the price and quantity data from markets that the firm chose to export to and ignored the endogenous market participation decisions would likely result in upward biased estimates of the distribution of ξ_f and downward biased estimates of the distribution of c_f.

these sources into a single firm-specific random variable $\eta_f = \eta(\xi_f, c_f, -\mu_f)$ which we will refer to as the **firm export participation component.** The final element of the empirical model is the specification of the stochastic relationship between the three sources of firm heterogeneity, $\xi_f, c_f,$ and η_f. We model the firm variables as:

$$(\xi_f, c_f, \eta_f) \tilde{} N(0, \Sigma_f)$$

where Σ_f is an unconstrained covariance matrix among the three components. This covariance matrix will provide estimates of the extent of firm heterogeneity in demand, marginal production cost, and fixed cost and the correlation between them.

The structural parameters can be grouped in a way that will facilitate estimation. Denote the set of demand and cost parameters that are common for all firms as $\Theta_1 = (\alpha_d, \tau_{dt}, \xi_k, \gamma_w, \gamma_{dt}, \gamma_k, \rho^u, \rho^v, \Sigma_e)$ and the participation parameters as $\Theta_2 = \psi$. Denote the firm effects as $(\xi, c, \eta)_f$ and let $g((\xi, c, \eta)_f | \Theta_3)$ be the joint distribution of the firm effects which depend on the parameter $\Theta_3 = \Sigma_f$.

The likelihood function (conditional on $(\xi, c, \eta)_f$) for firm f can be separated into a participation component, which only depends on the parameters Θ_2 and the firm participation component η_f, and the price and quantity components, which depend on Θ_1 and the firm demand and marginal cost terms ξ_f and c_f. In addition, because the participation decision depends on lagged participation status, we face an initial conditions problem, which is common in dynamic discrete choice models with persistent unobserved heterogeneity. Recognizing this, we express the likelihood function for the set of discrete destination decisions as:

$$lp(D_f | \Theta_2, \Theta_2^0, \eta_f, \eta_f^0) = \prod_d [\prod_{t=1}^{T} P(I_f^{dt} | \Theta_2, \eta_f, lnw_f^t, I_f^{dt-1})] P(I_f^{d0} | \Theta_2^0, \eta_f^0, lnw_f^0) \qquad (15)$$

The second term on the right-hand side of equation (15) represents the contribution of the initial year observations on the firm's export destinations I_f^{d0} to the likelihood. We use Heckman's (1981) method and specify a separate, flexible probabilistic model of initial export status with parameter vector Θ_2^0 and firm component η_f^0 and allow η_f and η_f^0 to be freely correlated.

We can express the likelihood for the price and quantity observations as:

$$ld(D_f|\Theta_1, (\xi, c, \eta)_f) = \prod_{d,k} [\prod_{t=\tau_0+1}^{\tau_1} h(u_{kf}^{dt}, v_{kf}^{dt}|u_{kf}^{dt-1}, v_{kf}^{dt-1}, \Theta_1, (\xi, c, \eta)_f)] \qquad (16)$$

Since each firm exports to different destinations during different years, the starting year that we observe active price and quantity data τ_0 and the ending year τ_1 is firm-destination-product specific.[9] Combining the participation, price, and quantity components, the likelihood for firm f (conditional on $(\xi, c, \eta)_f$) is then:

$$l(D_f|\Theta_1, \Theta_2, (\xi, c, \eta)_f) = lp(D_f|\Theta_2, \Theta_2^0, \eta_f, \eta_f^0)ld(D_f|\Theta_1, (\xi, c, \eta)_f) \qquad (17)$$

We could estimate the parameters $\Theta_1, \Theta_2, \Theta_3$ by specifying a distributional assumption on $g((\xi, c, \eta)_f|\Theta_3)$ and constructing the full likelihood for D_f by integrating over ξ, c, η.

$$l(D_f|\Theta_1, \Theta_2, \Theta_3) = \int l(D_f|\Theta_1, \Theta_2, (\xi, c, \eta))g((\xi, c, \eta)|\Theta_3)d\xi dc d\eta \qquad (18)$$

However, our primary interest is not to just estimate the common parameter vector $\Theta_1, \Theta_2, \Theta_3$ but to also construct an estimate of $(\xi, c, \eta)_f$ for each firm. The Bayesian MCMC methodology is very attractive for this purpose. Instead of integrating (ξ, c, η) out, we will sample from the joint posterior distribution over all the parameters, $\Theta_1, \Theta_2, \Theta_3$ and the firm components $(\xi, c, \eta)_f$ for all firms.[10]

The Bayesian approach requires we define a prior distribution on the parameters. Denote the prior on the common structural parameters as $P(\Theta_1, \Theta_2, \Theta_3)$. Assuming that $(\xi, c, \eta)_f$ is independent across all firms $f = 1...F$, the joint posterior distribution is:

$$P(\Theta_1, \Theta_2, \Theta_3, (\xi, c, \eta)_1, ..., (\xi, c, \eta)_F/D) \propto \left(\prod_f l(D_f|\Theta_1, \Theta_2, (\xi, c, \eta)_f)g((\xi, c, \eta)_f|\Theta_3))\right) P(\Theta_1, \Theta_2, \Theta_3)$$
$$(19)$$

Our goal is to characterize the posterior distribution, equation (19) numerically. This will allow us to describe the posterior distribution of both the Θ parameters and the demand, mar-

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[9]We also make the assumption that the initial year of the shocks u_{kf}^{d0}, v_{kf}^{d0} are independent of ξ, c, and η.

[10]In addition, our data often contains a large number of observations (products, years, and destinations) for each firm. In this case, the average marginal effects are robust to misspecification of the distribution of ξ and c. see Arellano and Bonhomme (2011).

ginal cost, and export participation component ξ_f , c_f, and η_f for each firm.

We use Markov Chain Monte Carlo (MCMC) simulation to generate a sequence of draws from this posterior distribution. As we detail in the Appendix, the model structure allows us to rely on Gibbs Sampling to simulate these draws sequentially for blocks of parameters. Specifically, for each iteration, we sample the firm heterogeneity components ξ_f, c_f, η_f conditional on the data and common parameters $\Theta_1, \Theta_2, \Theta_3$. We then draw Θ_1, Θ_2, and Θ_3 from their respective conditional posterior distributions which depend on the data and firm heterogeneity components ξ_f, c_f, η_f. Θ_1 includes the price elasticity parameters in the demand equation, which could potentially be subject to endogeneity bias resulting from correlation in ξ_f and c_f and in u_{fk}^{dt} and v_{fk}^{dt}. We rely on an empirical strategy outlined by Rossi, Allenby, and McCulloch (2007) to implement a sub-Gibbs Sampler within the step that draws Θ_1. This step effectively uses the lnw_f^t as instruments within our Bayesian framework.

4   Chinese Firm-Level Production and Trade Data

4.1   Data Sources

We will use the empirical model developed above to study the determinants of trade by Chinese firms operating in the footwear industry. The data we use in this paper is drawn from two large panel data sets of Chinese manufacturing firms. The first is the *Chinese Monthly Customs Transactions* from $2002-2006$ which contains the value and quantity of all Chinese footwear exporting transactions at the 6-digit product level. This allows us to construct a unit value price of exports for every firm-product-destination combination which makes it feasible to estimate demand models and construct a measure of each firm's demand component.

We supplement the trade data with information on manufacturing firms from the *Annual Survey of Manufacturing*, an extensive survey of Chinese manufacturing firms conducted each year by the Chinese National Bureau of Statistics. This survey is weighted toward medium and large firms, including all Chinese manufacturing firms that have total annual sales (including both domestic and export sales) of more than 5 million RMB (approximately $600,000). This survey is the primary source used to construct many of the aggregate statistics published in

the *Chinese Statistical Yearbooks.* It provides detailed information on ownership, production, and the balance sheet of the manufacturing firms surveyed. It includes domestically-owned firms, foreign-owned firms, and joint-venture firms operating in China as long as they are above the sales threshold. This data is important in our research to provide measures of total firm production, observable cost shifters including capital stocks and wage rates, and detailed ownership information. In China, these two data sources are collected by different agencies and do not use a common firm identification number. They do, however, each report the Chinese name, address, phone number, zip code, and some other identifying variables for each firm. We have been engaged in a project to match the firm-level observations across these two data sets using these identifying variables. To create instrumental variables used in our estimation, we further supplement data of rural wage, urban wage, and land transfer price of each city and its surrounding rural areas from the *Chinese City Statistical Yearbooks.*

In this paper we study the export behavior of firms in the footwear industry. We chose this industry for study because it is a major export industry in China, accounting for more than 70% of the footwear imports in the large markets in North America and Japan, has a large number of exporting firms, more than 2500 exporters were present in 2002, and was subject to a quota in the countries of the European Union during the first part of our sample period. We will use our estimated model to examine the sorting of firms along demand and cost both within and after the quota regime. In this industry there are 18 distinct 6-digit products and they can grouped into three 4-digit product classes: textile footwear, rubber footwear, and leather footwear. In this industry we are able to identify 738 unique firms in both the custom's and production data sets. Table 1 reports the number of these firms that are present in each of the sample years. This varies from 491 to 689 firms across years.

Table 1 - Number of Firms in the Sample			
Year	Number of Firms	Number of Exporting Firms	Export Rate
2002	490	329	0.670
2003	570	448	0.786
2004	688	609	0.885
2005	686	609	0.888
2006	658	541	0.822

The key demand variable is the market share of each firm/six-digit product in a destination. The market share of variety i in market dt is defined as the sales of variety i divided by the total imports of footwear from all supplying countries in market dt. The market shares for the Chinese firms in our sample are very small, more than 99% of the sample observations are below .004 and the maximum market share in any destination-year is .039. Given the few observations with larger market shares justifies our assumption of monopolistic competition in the firm's pricing decision.[11]

4.2   Empirical Patterns for Export Participation and Prices

In this subsection we summarize some of the empirical patterns of export market participation and export pricing for Chinese firms that produce footwear and discuss factors in the model that will help capture them. The second and third columns of Table 1 summarize the number and proportion of sample firms that export in each of the years. To be in the sample it is required that a firm export to at least one destination in two consecutive years. The number of exporting firms varies from 329 to 610 and the export rate varies from 0.67 to 0.89 over time.

Among the exporting firms, the destination markets vary in popularity. Table 2 reports the fraction of exporting firms in our sample that export to each destination between $2002 - 2006$. US/Canada is the most popular destination, with approximately half of the exporting firms in our sample exporting to these countries in any year. This is followed by Japan/Korea and Rest of Asia, where approximately 40 percent of the exporting firms sell. Japan/Korea has fallen slightly over time as a destination. Between 28 and 37 percent of the exporting firms sell in the Non-EU countries of Europe, Africa, and Latin America. Australia/New Zealand is the least popular destination market, with 19 percent of the Chinese exporters selling there on average, and a declining export rate over time. These numbers suggest that export profits will vary by destination market. Market size, tariffs, transportation costs, and degree of competition are all country-level factors that could contribute to differences in the profitability of destination

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[11] When estimating the demand curve we normalize this market share by s_0^{dt} the market share of a single product, waterproof footwear, aggregated over all suppliers to market dt. In effect, we treat the category of waterproof footwear as being produced by a single firm and the utility of this product is normalized to zero in market dt. In the demand function the price of this normalizing good varies across markets but will be absorbed in the destination-year dummies included in the empirical demand function.

markets and result in different export rates. They are captured in the theoretical model through the terms in $\ln \Omega^{dt}$ in equation (8) and the participation decision in each market will depend on the interaction of these country-level factors and the firm-level distribution of profitability.

Table 2 - Proportion of Exporting Firms By Destination						
Destination	2002	2003	2004	2005	2006	Average
US/Canada	.544	.533	.495	.493	.494	.512
Japan/Korea	.410	.384	.377	.380	.375	.385
Rest of Asia	.362	.413	.428	.430	.410	.408
Non EU Europe	.365	.359	.356	.374	.390	.369
Africa	.234	.275	.282	.351	.348	.298
Latin America	.274	.263	.280	.290	.298	.281
Australia/NZ	.219	.221	.177	.184	.159	.192

Table 3 provides evidence that the number of destinations a firm exports to and the popularity of the destination are related. The first column of the table reports the proportion of firms that sell in only one destination market (.348) through all seven destinations (.062). Slightly more than one-third of the firms sell in only one market. The fraction of firms selling in multiple markets declines monotonically as the number of markets increases from 18.2 percent selling in 2 destinations to 6.2 percent selling in all seven destinations. The remainder of the table gives the proportion of firms exporting to $n = 1, ...7$ destinations, conditional on exporting to one of the destinations. The destinations are ordered from most to least popular in terms of overall export rate. The table shows a clear correlation between number of destinations and the popularity of the destination. Firms that export to the most popular destinations, US/Canada and Japan/Korea, are most likely to export to only one destination. The firms that export to the least popular destinations, Africa, Latin American, and Australia/NZ, are most likely to export to a large number of destinations. Firms that export to the Rest of Asia and nonEU Europe are in the middle, more likely to export to one or two destinations than the Africa, Latin American, Australia/NZ exporters, but less likely than the US/Canada and Japan Korea exporters. This pattern is consistent with underlying sources of firm heterogeneity that persist across all the firm's destination markets. Firms with demand, marginal cost, and fixed cost components that allow them to be profitable in difficult markets, that is ones with low

aggregate demand or high transport and entry costs, will also tend to be profitable in more popular markets and export to a larger total number of markets. This pattern is also consistent with evidence in Eaton, Kortum, and Kramarz (2011) who show that French firms export to a hierarchy of countries and conclude that firm-level factors that persist across markets is an important factor that generates the dependence in the set of destination markets. Firm-level demand and cost components play a major role in the empirical model developed here.

Table 3 - Frequency Distribution of Total Number of Destinations							
Number Destinations n		Conditional on Exporting to:					
(overall frequency)	US/Can	Jap/Kor	Rest Asia	non EU	Africa	Lat Am	Aust/NZ
1 (.348)	.209	.323	.095	.123	.033	.040	.063
2 (.182)	.159	.108	.153	.136	.117	.056	.143
3 (.134)	.130	.099	.172	.136	.168	.119	.080
4 (.112)	.123	.112	.164	.158	.178	.181	.134
5 (.102)	.143	.112	.149	.184	.182	.220	.170
6 (.061)	.113	.121	.134	.114	.154	.181	.116
7 (.062)	.123	.125	.134	.149	.168	.203	.295

While Table 3 provides evidence that firm-level factors help determine the extensive margin of trade, we also find evidence that the intensive margin of trade is affected. Table 4 investigates the individual firm's price and quantity decision to highlight the important dimension of firm heterogeneity in the data. The table reports the R^2 from OLS regressions of log price and log quantity on combinations of product, destination, year, and firm dummies in explaining price and quantity variation. The one-way regressions show that the product dimension accounts for 33.7 percent of the sample variation in log price and 10.7 percent in log quantity. By itself, the destination dimension accounts for just over 1 percent of the sample variation in prices and just under 5 percent in quantity and the time dimension accounts for virtually no variation in prices or quantities. Most importantly, the firm dimension accounts for the vast majority of the sample variation: 76.5 percent of the price variation and 44.5 percent of the quantity. Adding characteristics sequentially, beginning with the product dimensions, we see that destination and year contribute little additional explanatory power in the price and quantity regressions. In contrast the firm dimension continues to contribute substantial explanatory power for both variables. Overall, the table simply illustrates that most of the micro-level price and quantity

variation is accounted by across-firm differences, some by differences in the type of product (leather vs. rubber vs. plastic shoes), and very little by time and destination. This reinforces the focus of our empirical model on characterizing the extent of firm heterogeneity in demand and cost conditions.

Table 4 - Source of Price and Quantity Variation		
R^2 from OLS regressions		
Categories of Controls	log price	log quantity
Four-Digit Product (3 categories)	.337	.107
Destination (7 areas)	.014	.049
Year (5 years)	.002	.002
Firm (738 firms)	.765	.445
Product, Destination	.343	.145
Product, Destination, Year	.346	.146
Product, Destination, Year, Firm	.825	.492

We also find that the extensive margin and the intensive margin are correlated in a way that is consistent with firm-level heterogeneity that persists across markets. Table 5 reports coefficients from regressions of log price and log quantity on dummy variables for the number of destination markets. All coefficients are relative to firms with only one destination and the regressions include a full set of product, year, destination dummies. The first column of the table shows that firms that export to three to six destinations have prices, on average, that are statistically significantly higher than firms that export to one destination, but prices for firms that export to two or seven destinations are not significantly different. The second column shows that, with the exception of three destinations, the average firm export quantity to each market also rises as the number of destinations increases. In these cases, the average quantity of sales in in each market are between 11 and 51 percent higher than the base group.

Table 5 - Price and Quantity Versus Number of Destinations (standard errors)		
Number of destinations	log price	log quantity
2	.020 (.024)	.109 (.086)
3	.133 (.025)	-.172 (.088)
4	.082 (.025)	.173 (.088)
5	.107 (.024)	.145 (.084)
6	.172 (.025)	.507 (.088)
7	.009 (.022)	.281 (.079)
Regressions include a full set of year,product,destination dummies		

Overall, Table 5 shows that the intensive margin, the average quantity of sales in each market, is positively related to the number of destinations the firm exports to, but the pattern is noisy. The complex relationship between the quantity of sales and the extensive margin indicates that there is likely a role for multiple sources of firm-level heterogeneity. Firms with low fixed costs of exporting would sell in more destinations, other things equal, but they would also require higher demand or lower marginal cost to explain the higher quantity of sales. The price is also higher for firms that export to more markets, except for the seven destinations. This is not consistent with low marginal cost and low price being the sole determinant of export participation and price. This is consistent with underlying firm differences in demand: firms with high demand components export to more markets and sell more, but also have higher marginal costs and thus higher prices. Overall, the empirical patterns summarized in Tables 3-5 suggest that firm-level differences in profitability that persist across destination markets is a likely contributor to the export decisions on both the extensive and intensive margins for Chinese footwear exporters, but it is not possible to identify the source of the firm differences from this evidence, so we turn to estimation of a structural model with distinct firm demand, marginal cost, and fixed cost components.

5 Empirical Results

In this section we report estimates of the system of demand, pricing, and market participation equations using the Bayesian MCMC methodology. We report the posterior means and standard deviations of the parameters that are common across firms, Θ_1, Θ_2, and Θ_3 defined in section 3, and summarize the role of the three sources of firm heterogeneity in generating price, quantify and export participation differences across firms.

5.1 Demand Estimates

Table 6 reports estimates of the demand curve parameters, equation (4) which include the destination-specific price parameters α_d and group demand shifters ξ_k. The demand elasticity in each market is $-\alpha_d$ and the markup, the ratio of price to marginal cost, is $\alpha_d/(\alpha_d-1)$. The first three columns of results correspond to our system of equations using the Bayesian MCMC

methodology where each column uses a different set of instrumental variables to control for the endogeneity of the output price.[12] The column labeled IV1 uses the log of the urban wage and the log of the rural wage for manufacturing workers in the city where the firm is located. IV2 adds the log of the local land rental price to the instrument set and IV3 further adds the log of the firm's capital stock. The IV1 and IV2 instruments vary at the city-year level. The third set of instruments includes one firm-level variable, the capital stock, in the set.[13] For comparison, the final two columns report OLS and IV estimates, using the IV1 instrument set, of the demand curve. To be consistent with the model assumption of ξ_f, we use a random effect IV specification.

Focusing on the system estimates, we observe that the demand elasticity for each country varies little across the different instrument sets. Using the results for IV2, we see that the demand elasticities $-\alpha_d$ vary from -2.381 to -3.272 across destination countries. They are highest in the low-income destinations, Africa, Latin America, and the Rest of Asia, where they vary between -2.974 and -3.272. This implies lower markups in these destinations with the ratio of price to marginal cost varying from 1.440 to 1.506. The higher-income destinations, US/Canada, Australia/NZ, Japan/Korea, and non-EU Europe, have demand elasticities that vary between -2.381 and -2.932 and markups that all exceed 1.518. Finally, the two product group coefficients imply that consumers get higher utility from leather shoes and lower utility from textile shoes, relative to rubber shoes.

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[12]Since we have a structural pricing equation, this is essentially a standard Hierarchical Bayes model. We include the name IV to highlight the role of cost shifters in the pricing equation for model identification.

[13]We do not include the firm's own wage rate as an instrument because it can reflect the composition of the labor force in the firm and this could be correlated with the firm demand and cost component.

Table 6 - Demand Curve Parameter Estimates (standard error)					
	Bayesian System of Equations			Demand Equation	
Parameter	IV1	IV2	IV3	OLS	IV1
- α_d - US/Canada	-2.720 (0.319)	-2.804 (0.319)	-2.693 (0.348)	-0.657 (0.075)	-1.735 (0.845)
- α_d - Japan/Korea	-2.850 (0.326)	-2.932 (0.326)	-2.818 (0.356)	-0.633 (0.096)	-2.140 (1.474)
- α_d - Australia/NZ	-2.629 (0.343)	-2.708 (0.342)	-2.589 (0.366)	-0.259 (0.128)	-2.083 (0.909)
. - α_d - Rest of Asia	-2.943 (0.326)	-3.028 (0.327)	-2.916 (0.356)	-0.973 (0.082)	-2.949 (0.644)
- α_d - Non-EU Europe	-2.297 (0.325)	-2.381 (0.325)	-2.264 (0.349)	-0.198 (0.089)	-1.157 (0.699)
- α_d - Africa	-3.186 (0.334)	-3.272 (0.334)	-3.156 (0.359)	-1.064 (0.097)	-3.286 (0.687)
- α_d - Latin America	-2.889 (0.335)	-2.974 (0.334)	-2.856 (0.360)	-0.800 (0.100)	-2.941 (0.654)
ξ_g - leather	0.303 (0.242)	0.356 (0.244)	0.288 (0.254)	-1.032 (0.069)	0.110 (0.384)
ξ_g - textile	-0.899(0.162)	-0.908 (0.160)	-0.902 (0.161)	-0.912 (0.069)	-0.826 (0.091)
The models include a full set of destination*year dummies					

In contrast, the OLS estimates of the price elasticity are substantially closer to zero, varying from -0.198 to -1.064. This finding of more inelastic demand is consistent with the expected positive bias in the demand elasticity due to the endogeneity of prices when using the OLS estimator. The IV estimator of the simple demand equation produces estimates of $-\alpha_d$ that are much closer to the system IV estimates despite having larger standard errors.

5.2 Pricing Equation Estimates

Table 7 reports parameter estimates of the pricing equation (6). These include coefficients that shift the marginal cost function including the local wage rate for urban and rural workers, the land rental price, and the firm's capital stock, as well as product dummy variables. The coefficients on both wage rates are always positive, as expected, but highly significant. When the land rental price is added to the marginal cost specificiation (IV2) it is also positive and significant but becomes insignificant when the capital stock is also added as a marginal cost shifter (IV3). The sign of the capital coefficient in the last case is positive, which is not consistent with it being a shifter of the short-run marginal cost function.[14] The product

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[14]Because we do not use any data on the cost of the firm's variable inputs, but instead estimate the cost function parameters from the pricing equation, this coefficient will capture any systematic difference in prices with firm size. It is important to emphasize that the estimation has already controlled for firm-specific factors in cost (c_f) and demand (ξ_f) so the capital stock variable is measuring the effect of variation in firm size over time which is likely to capture factors related to the firm's investment path and not just short-run substitution between fixed and variable inputs.

dummies indicate that leather footwear prices are, on average 60 percent higher and textile footwear prices are 5.5 percent lower than the base group, rubber footwear.

The remaining parameters summarize the serial correlation structure in the shocks to the demand and pricing equations. The autoregressive coefficient in the demand shocks ρ_u is .640 (.009) and in the cost shocks ρ_v is .668 (.011). These indicate that, even within a firm, some product-market combinations tend to consistently do better. The final three parameters in the table indicate that the demand shock has a much larger variance than the cost shock and there is a positive covariance between the two shocks. The covariance between eu and ev is .177 and the correlation coefficient is .418. The fact that the correlation is positive indicates that price will be positively correlated with the transitory demand shock u, demand elasticity estimates will be biased toward zero if this source of endogeneity is not controlled for by instrumental variables. This bias was seen in the OLS estimates in Table 6.

Table 7 - Pricing Equation Parameter Estimates			
	Bayesian System of Equations		
	IV1	IV2	IV3
$ln(urbanwage)_{ft}$	.200 (.022)	.180 (.024)	.175 (.024)
$ln(ruralwage)_{ft}$	.041 (.010)	.038 (.010)	.039 (.010)
$ln(landrentalprice)_{ft}$		.014 (.007)	.011 (.007)
$ln(capital)_{ft}$			.005 (.002)
Product Group Dummies (γ_k)			
Leather Shoes	.597 (.032)	.596 (.031)	.596 (.031)
Textile Shoes	-.054 (.037)	-.054 (.036)	-.055 (.036)
Transitory Shocks (ρ_u, ρ_v, Σ_e)			
ρ_u	.640 (.009)	.640 (.009)	.640 (.009)
ρ_v	.671 (.011)	.669 (.011)	.669 (.011)
$Var(eu)$	2.107 (.114)	2.134 (.115)	2.096 (.114)
$Var(ev)$	.084 (.002)	.084 (.002)	.084 (.002)
$Cov(eu, ev)$	.169 (.026)	.177 (.026)	.167 (.028)
The model includes a full set of destination*year dummies			

5.3 Market Participation

The third equation in our empirical model is the probability of exporting, equation (13), and the parameter estimates are reported in Table 8. All the cost shifters have negative coefficients as expected. The firm's product mix, measured as the combination of the product coefficients ξ_k

and γ_k in demand and cost equations, and defined in equation (8), is also highly significant as a determinant of the export decision. Firms producing products with high appeal or low cost have higher probabilities of exporting. Finally, as seen in every empirical study of exporting, past participation in the destination market raises the probability of exporting to that destination in the current period. As was seen in Tables 6 and 7, the coefficients are not sensitive to the set of cost shifters that are used.

The bottom half of the table reports the coefficients for the initial conditions equation. This is included to recognize that the participation variable in the first year we observe the firm in a market is not exogenous, but is likely to be determined by the same fixed cost factors as the later years. The cost shift variables for the wage rates and land rental price and the product mix variable have the same signs as in the participation equation for the latter years. The capital coefficient is positive and significant in the initial year. All of the coefficients are larger in absolute value in the inital conditions equation indicating that observed firm characteristics play a larger role in explaining firm differences in participation than in the latter years when the past participation variable captures much of the role of firm heterogeneity in participation. Finally, the covariance between η_f and η_f^0 is positive, reflecting persistence in the export participation component over time.

Table 8 - Export Market Participation Equation			
	Bayesian System of Equations		
Dependent Variable	IV1	IV2	IV3
$ln(urbanwage)_{ft}$	-.458 (.077)	-.448 (.081)	-.433(.081)
$ln(ruralwage)_{ft}$	-.081 (.041)	-.076 (.041)	-.071 (.042)
$ln(landrentalprice)_{ft}$		-.007 (.028)	-.004 (.028)
$ln(capital)_{ft}$			-.005 (.013)
product mix $\sum_{k \in K_f} r_k^d$	.367 (.036)	.366 (.036)	.371 (.037)
past participation I_f^{dt-1}	2.071 (.030)	2.069 (.029)	2.080 (.030)
Initial Conditions			
$ln(urbanwage)_{f0}$	-.907 (.156)	-.859 (.159)	-.717 (.148)
$ln(ruralwage)_{f0}$	-.516 (.131)	-.441 (.136)	-.512 (.130)
$ln(landrentalprice)_{f0}$		-.162 (.063)	-.109 (.059)
$ln(capital)_{f0}$			.139 (.022)
product mix $\sum_{k \in K_f} r_k^d$	.571 (.063)	.580 (.065)	.594 (.059)
$Cov(\eta_f, \eta_f^0)$	1.327 (.319)	1.462 (.374)	1.135 (.253)
The model includes a full set of destination*year dummies			

5.4 Firm Demand, Marginal Cost, and Fixed Cost

The empirical model and estimation method produce estimates of the firm-specific demand, marginal cost, and fixed cost factors, ξ_f, c_f, and η_f. It is important to emphasize that all three equations, including the export participation equation, are helpful in identifying the joint distribution of the firm components. Table 9 reports the posterior mean and standard deviation of the variance matrix of the firm effects Σ_f.

Table 9 - Posterior Distribution of Σ_f		
	Mean	Standard Dev
$Var(\xi_f)$	3.687	(0.613)
$Var(c_f)$	0.341	(0.129)
$Var(\eta_f)$	0.136	(0.024)
$Cov(\xi_f, c_f)$	0.795	(0.129)
$Cov(\xi_f, \eta_f)$	0.099	(0.046)
$Cov(c_f, \eta_f)$	0.012	(0.012)

The posterior variances are 3.687 for the demand component and 0.341 for the cost component implying that producer heterogeneity is much more substantial on the demand side than on the cost. The across-firm hetergeneity in market shares is leading to substantial variation in the estimated ξ_f across firms while the heterogeneity in prices leads to a much smaller degree of dispersion in c_f. The variance of η_f cannot be interpreted in the same way because it is estimated from a discrete choice equation. The parameters in the participation model, equations (12) and (13) are normalized by the variance of the shock ε_f^{dt}.

The final three parameters reported in Table 9 are the covariances between the three firm components. The covariance between the demand and cost components is .795, implying that firms with relatively high demand components also have higher costs and prices which is consistent with the firm making costly investments that raise marginal cost, such as improving product quality or building a stock of customers, in order to increase demand. The firm entry component is also positively correlated with both the demand and cost components.

As explained in the theory section, the cost heterogeneity term c_f is the sum of firm-level costs to produce higher demand $h(\xi_f)$ as well as a pure marginal cost component ω_f. The entry heterogeneity term η_f is a function of the cost and demand terms as well as a pure entry cost component μ_f. If we approximate these relationships as linear functions, we can express

the three measured firm components in terms of three orthogonal terms, ξ_f, ω_f, and μ_f.[15]

$$\xi_f = \xi_f \tag{20}$$

$$c_f = a_1\xi_f + \omega_f.$$

$$\eta_f = a_2\xi_f + a_3c_f - \mu_f$$

There is a one-to-one mapping from the six elements of Σ_f in Table 9 to the six parameters, a_1, a_2, a_3 and variances of the three orthogonal terms ξ_f, ω_f, and μ_f. Solving for a_1, a_2, a_3 gives $a_1 = 0.216$, $a_2 = 0.038$, and $a_3 = -0.053$. The variances are $V(\xi_f) = 3.687$, $V(\omega_f) = .170$, and $V(\mu_f) = 0.127$ The positive value of a_1 implies that high demand firms are also high cost firms and will therefore have higher prices. The marginal cost component ω_f accounts for one-half of the variance in the cost term c_f while the demand component $a_1\xi_f$ accounts for the other half of cost variation. The positive value of a_2 and negative value of a_3 imply that high demand firms will be more likely to enter markets while high cost firms will be less likely. Together, variation in ξ_f and c_f account for very little (7%) of the variation in η_f and, instead, variation in the fixed cost component μ_f is the major contributor.

We can also use the model estimates to assess the role of ξ_f and ω_f on the intensive margin of trade. We can explain the fraction of the variance of log market share, log price, and log revenues due to variation in ξ_f and ω_f in terms of the first two lines of the decomposition, equation (20). The log market share components are:

$$D_\xi = V((1 - \alpha_d a_1)\xi_f)/V(\ln(s_{kf}^{dt})) \tag{21}$$

$$D_\omega = V(-\alpha_d\omega_f)/V(\ln(s_{kf}^{dt}))$$

The log market price components are:

$$P_\xi = V(a_1\xi_f)/V(\ln p_{kf}^{dt}) \tag{22}$$

$$P_\omega = V(\omega_f)/V(\ln p_{kf}^{dt})$$

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[15]The assumption that η_f, ξ_f and c_f are multivariate normal implies that the mean of η_f is a linear function of ξ_f and c_f. In the participation probit, including η_f implies that ξ_f and c_f have a linear effect on the latent value of exporting.

The log market revenue components are:

$$R_\xi = V(1 + (1 - \alpha_d)a_1)\xi_f)/V(\ln r_{kf}^{dt}) \qquad (23)$$

$$R_\omega = V((1 - \alpha_d)\omega_f)/V(\ln r_{kf}^{dt})$$

The six components are reported in Table 10. The first column reports the values for the demand component D_ξ, P_ξ, and R_ξ and the second column reports the values with respect to the marginal cost shock D_ω, P_ω, R_ω. For the quantity shares, the firm demand component contributes 10.4 percent of the variation while the productivity component contributes twice as much, 22.5 percent, to the variation in the log of the market shares. The reason that the demand component is less important in this decomposition is that it captures two offsetting effects: a firm with a higher ξ_f will have higher demand, but also higher prices. In the decomposition of log price in row 2, the contributions of ξ_f and ω_f are very similar, 29.8 and 25.3 percent, respectively, and together account for over 50 percent of the price variation observed in the export data. Finally, in terms of log revenue, the firm demand variation accounts for 29.8 percent of total variation in sales, while the marginal cost component accounts for another 11.6 percent. Overall, both the firm-level demand and marginal cost components are important sources of the variation in export quantities, prices, and sales among exporting firms. Together they account for over 30 percent of market share variation, 40 percent of revenue variation, and more than 50 percent of price variation.

Table 10: Intensive Margin

Fraction of Variance Contributed by ξ_f and ω_f (standard error)		
	Demand ξ_f	Marginal Cost ω_f
log quantity share (D)	0.104 (0.032)	0.225 (0.027)
log price (P)	0.298 (0.053)	0.253 (0.039)
log revenue (R)	0.298 (0.046)	0.116 (0.024)

The demand and marginal cost components will all contribute to variation in firm profits across destinations and thus affect the extensive margin of exporting. However, the extensive margin is also affected by the variation in the fixed cost μ_f across firms. The relative importance of the three firm components on the extensive margin of exporting can be seen by calculating how the probability of exporting changes with variation in each component. Table 11 reports these contributions.

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Table 11: Extensive Margin			
Percentage Change in the Probability of Exporting (standard error)			
Change in Firm Component	Demand ξ_f	Marginal Cost ω_f	Fixed Cost μ_f
P10 to P90	2.84 (1.29)	-1.23 (1.37)	22.32 (2.01)
P25 to P75	1.16 (0.53)	-0.49 (0.55)	8.52 (0.77)

The first row of the table shows that if we move the firm component from the 10th to the 90th percentile of its distribution, the probability of exporting will rise, on average, by 2.84 percentage points for the demand component, fall by 1.23 percentage points for the marginal cost component and rise by 22.32 percentage points for the fixed cost component. Clearly, difference in the fixed cost component μ_f across firms is the major source of firm-level differences in the probability of exporting. However, the demand component still has some small but statistically significant impact on the extensive margin of trade. The reason that demand is more important than cost is consistent with the fact that the variance of ξ_f is the more important determinant for revenue (and subsequently profit). The second line of the table, shows that if we use more modest movements in the firm component, from the 25th to 75th percentile of their respective distributions, the percentage change in the probability of exporting is reduced to approximately one-third of the magnitude in the first row. In this case, differences in the firm fixed cost will result in an increase in the probability of exporting of 8.52 percent.

To summarize, this section provides estimates of structural demand, pricing and export participation equations for Chinese footwear exporting firms across seven destination markets. Our econometric methodology provides a way to estimate unobserved firm-level demand, marginal cost, and fixed cost components. We find that the firm-level fixed cost is the primary determinant of the entry decision but the demand and marginal cost measures are very important in explaining the price, market share, and revenue variation across firms, destination markets, and time. The firm-level demand component has larger variance across firms than the marginal cost component but both play a significant role in generating differences in firm profitability in each market. The cost component is particularly important in accounting for differences in export quantities across firms and both components are of approximately equal importance in explaining across-firm export price differences. In the next section we study the response of the 738 firms in our sample to the removal of the EU quota on footwear exports

from China and ask whether firm demand and cost heterogeneity plays a role in explaining the subsequent entry, exit, and growth patterns

6 Analyzing the EU Quota Restriction on Chinese Footwear Exports

One feature of the environment faced by the Chinese footwear exporters was a quota on total footwear imports in the European Union that was in place during the first half of our sample. In this section we analyze the mix of firms that export to the EU and summarize how this compares during and after the quota period. We have not used the data on exports to the EU in estimating the structural parameters and constructing the firm demand and cost indexes and this section provides some validation that the estimates are capturing useful dimensions of firm profit heterogeneity.

Restrictions on Chinese footwear exports to the EU countries date back to the 1990's. During the the first three years of our data, 2002-2004, there was an EU quota on total Chinese footwear imports. The quota applied to all three product categories and substantially constrained total exports from China. The quota was adjusted upward between 10 and 20 percent each year following China's entry into the WTO in late 2001. In 2005 it was removed and this expiration date was widely known ahead of time. As a consequence, part of the response of Chinese exporters was already observed in 2004. The quota was monitored by the EU commission. It was directly allocated across importing firms with 75 percent of the allocation given to "traditional importers," firms that could prove they imported the covered products from China in previous years. The remaining 25 percent of the allocation was given to "non-traditional importers," basically new importing firms, but they were constrained to a maximum of 5,000 pairs of shoes per importer. In effect, the quota limited the ability of new importing firms to gain access to Chinese footwear exports. In addition, when the total application by the importers exceeded the aggregate quota, as is the case for our sample years, applications were met on a pro rata basis, calculated in accordance with each applicant's share of the total imports in previous years.

These quota restrictions impacted the export decision of Chinese footwear producer's in

important ways. First, given the preferential treatment in quota allocation to "traditional importers," there was a lack of presence of "non-traditional" importers. Furthermore, the quota may also constrain the traditional importers' choice of which Chinese export firm to buy from. If it takes time for traditional importers to switch their Chinese suppliers then any disruption in their import quantity in one year would adversely affect their quota allocation in the next year. This suggests that traditional importers may not have been completely unconstrained in their choice of Chinese firm to buy from and, more generally, that the export history of a Chinese supplier in the EU may have played a more important role than in other non-restricted markets. Overall, the quota is likely to have discouraged the entry of new exporting firms to the EU and slowed the reallocation of market share towards high ξ and low c firms among incumbent Chinese producers. Second, from the perspective of Chinese producers,the binding quota restriction implied a constrained profit maximization problem. The shadow cost of the quota restriction translates into a per unit trade cost incurred by producers. In addition to lowering the overall profitability of Chinese exporters in the EU market, the per-unit trade cost also has a composition effect that favors firms with a higher unit price (and higher demand because of the positive correlation between ξ and c) in the quota regime.

In this section we document the large increase in aggregate exports to the EU by Chinese firms in our sample and quantify the firm adjustment in both the extensive and intensive margins using the demand and cost indexes we constructed with data from the non-EU markets. Table 13 shows the total exports to the EU by the 738 firms in our sample for the years 2002-2006. For comparison, the total exports of these same firms to the US/Canada and Japan/Korea are presented. It is clear from the table that there was a gradual increase in exports to the EU for all three categories of footwear that were under EU quota constraints from 2002-2003 followed by a substantial increase in 2004 and 2005. In contrast, the magnitude of this expansion was not present in either the U.S. or Japanese export markets.[16]

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[16]There was another change in policy that affected leather footwear imports to the EU in 2006. An anti-dumping tariff was placed on Chinese leather footwear exports and this contributed to the observed decline in export quantity of this product in 2006.

Table 13 - Quantity of Footwear Exports by Sample Firms (millions of pairs)						
	2002	2003	2004	2005	2006	Growth Rate 2002-2006
Plastic Footwear[a]						
EU	9.36	16.3	24.7	32.8	37.4	299%
Japan/Korea	13.0	14.3	17.3	18.5	20.5	58%
US/Canada	14.0	23.4	33.3	29.5	38.5	175%
Leather Footwear[b]						
EU	1.16	1.92	3.03	10.2	6.36	450%
Japan/Korea	6.41	6.97	5.48	4.05	3.72	-42%
US/Canada	7.68	7.80	9.85	14.1	12.2	58%
Textile Footwear[c]						
EU	2.42	5.87	11.9	15.9	21.7	799%
Japan/Korea	20.8	20.4	23.7	26.6	27.2	31%
US/Canada	16.6	16.8	21.8	21.7	29.9	80%
[a]product 640299, [b] 640391 and 640399, [c] 640411 and 640419						

The changes in the quota constraint were accompanied by firm adjustment on both the extensive and intensive margins. The top panel of Table 14 summarizes the export participation rate for our sample of firms in the EU, US, and Japanese markets. The participation rate in the EU market rose from .355 to .541 over the sample period, while it increased from .498 to .536 in the U.S. and remained virtually unchanged at approximately .430 in Japan. Relaxing the quota was accompanied by net entry of Chinese exporting firms into the EU market. The lower panel of the table shows the average size (in thousands of pairs of shoes) of continuing firms in the three markets in each year. In each destination there is a substantial increase in the size of the exporting firms from 2002-2005, followed by a drop in 2006. Across the three destinations the proportional increase over the whole period was larger in the EU (134 percent) than in the US (39 percent) or Japan (28 percent). There is a significant increase in the average size of the Chinese firms sales in the EU market as the quota was relaxed.

Table 14:	Source of Export Expansion by Year, Destination				
	2002	2003	2004	2005	2006
Extensive Margin (Prop. firms exporting to destination)					
EU	.355	.440	.477	.536	.541
US/Canada	.498	.560	.509	.536	.536
Japan/Korea	.420	.432	.440	.440	.432
Intensive Margin of Long-Term Exporters[a]					
EU	55.6	89.8	140.7	161.0	130.2
US/Canada	74.2	96.5	132.6	128.0	103.7
Japan/Korea	95.6	107.9	130.8	141.2	122.6
[a]Median quantity, thousands of pairs					

Table 14 implies that there is reallocation of market shares among the set of firms that are selling to the EU market. The next question we address is whether this reallocation is related to the underlying firm demand and cost indexes.[17] In Table 15 we first examine reallocation on the extensive margin resulting from the entry and exit of the exporting firms from the EU market then, in Table 16, we summarize reallocation on the intensive margin reflecting changes in the size of continuing exporters.

Given our MCMC approach, for each set of simulations of ξ_f^s, ω_f^s, or μ_f^s, we assign the firms into 5 bins. For the demand index, we assign the firm to bin 1 if its value of ξ_f is in the lowest 20 percent of firms. For the cost indexes we assign the firm to bin 1 if its cost index is in the highest 20 percent of firms. In this way, firms assigned to bin 1 will have the lowest profits in a particular dimension. The remaining bins each contain 20 percent of the firms where profits will be increasing as we move to higher bins. Firms assigned to bin 5 will have the highest demand and lowest cost indexes and thus the highest profits. In Table 5 we report turnover patterns for each bin based on averages of all the simulations.[18]

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[17]It is not possible to construct the index of firm profitability for the firms in the EU market because we do not have an estimate of the demand parameter α_d in this destination market. We will instead focus on the separate comparisons of demand and cost.

[18]Standard errors of these summary statistics are also calculated but we chose not to report them due to space limit.

Table 15: The Source of Adjustment in the Number of Firms Exporting to the EU

	Net Entry Rate[a]	Entry Rate[b]				Exit Rate[c]			
ξ_f	2002-06	2002-03	2003-04	2004-05	2005-06	2002-03	2003-04	2004-05	2005-06
1 - low	0.146	0.153	0.209	0.218	0.123	0.325	0.316	0.280	0.257
2	0.214	0.167	0.237	0.221	0.145	0.223	0.235	0.179	0.229
3	0.277	0.192	0.270	0.230	0.184	0.167	0.160	0.155	0.188
4	0.312	0.222	0.284	0.250	0.205	0.112	0.141	0.155	0.166
5 - high	0.305	0.220	0.290	0.268	0.197	0.074	0.157	0.139	0.167
ω_f									
1 - high	0.241	0.234	0.232	0.261	0.172	0.118	0.187	0.173	0.209
2	0.252	0.213	0.255	0.239	0.189	0.101	0.176	0.181	0.190
3	0.262	0.192	0.261	0.225	0.177	0.147	0.205	0.174	0.188
4	0.279	0.174	0.259	0.215	0.154	0.220	0.204	0.165	0.180
5 - low	0.287	0.147	0.267	0.239	0.145	0.364	0.199	0.180	0.216
μ_f									
1-high	0.138	0.130	0.166	0.132	0.129	0.279	0.332	0.364	0.325
2	0.207	0.144	0.203	0.198	0.150	0.261	0.267	0.287	0.267
3	0.262	0.171	0.234	0.252	0.167	0.218	0.230	0.219	0.224
4	0.331	0.221	0.296	0.315	0.198	0.165	0.181	0.144	0.184
5-low	0.383	0.338	0.491	0.421	0.293	0.097	0.101	0.050	0.115

[a] change in the total number of exporting firms 2002-2006 relative to number of exporting firms 2002
[b] number of new exporting firms in year t relative to number of nonexporting firms in year $t-1$
[c] number of firms that exit exporting in year t relative to the number of exporting firms in year $t-1$

The first column of Table 15 shows that net entry is positive for all categories of firms from 2002-2006 reflecting the loosening of the quota restrictions and the overall expansion of exports to the EU. Net entry over the whole period shows a compositional shift toward firms with high demand, low marginal cost, and low fixed cost indexes.   For example, firms with the lowest demand indexes had a net entry rate of .146 while firms with the highest demand indexes had a net entry rate of .305. The differences across profit bins is larger for the demand index (.146 to .305) and fixed cost index (.138 to .383), and is weaker for the marginal cost index (.241 to .287). This also reflects the relatively low dispersion in the marginal cost index, so that there is less profit heterogeneity across firms in this dimension to begin with.

The remainder of the table shows how this net change over the whole period is divided among years and among entry and exit flows. Focusing on the demand index in the top panel, we see that the entry rate increases monotonically as ξ increases (move from bin 1 to bin 5)

within each year. There is a higher entry rate by firms with high demand indexes. The entry rates are highest in 2003-04 and 2004-05 just as the quota is removed, and drop in all categories by 2005-06, suggesting a fairly rapid response on the extensive margin to the quota removal. The exit rate is decreasing as ξ increases and is particularly high for the firms with the lowest demand indexes, bins 1 and 2. While there is not a strong pattern in the exit rate over time, both entry and exit rates contribute to the large increase in net entry rates as the demand index ξ increases. Reallocation on the extensive margin following the quota removal is toward firms with high demand indexes.

The second panel summarizes variation from high to low marginal cost indexes. The pattern in the entry rate as ω increases is not stable across years. In 2002-2003 and 2004-2005 and for the top 4 categories in 2005-2006, it falls as ω declines, indicating that firms with higher marginal costs have higher entry rates in these years. In 2003-04 the pattern is reversed, however, the differences in the entry rates across bins are not very substantial in most years. This weak relationship with ω is also seen in the exit rates. The exit rates do not move monotonically as ω increases and do not shift systematically for all categories between most pairs of years. Overall, firm differences in the marginal cost indexes do not translate into strong entry or exit patterns.

The final panel summarizes entry and exit patterns as fixed costs fall. The pattern is similar to what is observed for the demand indexes but there are even larger differences across bins. The entry rate increases monotonically increases and the exit rate falls as fixed costs fall in every year. Both entry and exit rates contribute to the pattern on net change seen in column 1.

Overall, as the quota is removed, nonexporters with relatively high demand and low fixed cost indexes move into the EU market while those with low demand and high fixed costs are more likely to abandon it. This movement starts before the quota is officially removed in 2005 and persists into 2006. Variation in the marginal cost index is not a strong predictor of adjustment on the extensive margin.

The quota removal can also lead to adjustment on the intensive margin as the initial group of exporters expand or contract their sales in response to the changing market conditions. Table

16 focuses on the set of firms that are present in the EU market in 2002 and follows their growth and survival through 2005. The first column reports the average output growth rate of the surviving firms in each demand, marginal cost, and fixed cost bin. The second column reports the survival rate over the time period for the same group of firms. The demand results are clear: the average firm growth rate increases substantially as the demand index increases. Continuing exporters in the lowest demand category grew 1.2 percent, on average, over the period. In contrast, firms in the highest category increased their footwear exports to the EU an average of 13.7 percent. The survival rate also increases monontonically from 62.7 to 79.4 percent as demand increase. There is a clear reallocation of export sales toward the firms with higher demand indexes. In contrast, the variation in the export growth rate and survival rate with the marginal cost index does not have a clear pattern. Firms in the three highest cost categories grew between 8.8 and 10.3 percent, while the firms in the two low cost categories grew 4.4 and 6.1 percent. The survival rate declines as the cost index falls, until the lowest cost category. There is no evidence that output was being relallocated to toward firms with the lowest marginal cost indexes.

Table 16 - Quantity Adjustment by Existing Exporters		
Demand ξ_f	Average Growth Rate of Quantity	Survival Rate
1 - low demand	0.012	0.627
2	0.047	0.669
3	0.088	0.736
4	0.101	0.754
5 - high demand	0.137	0.794
Marginal Cost ω_f		
1 - high cost	0.089	0.753
2	0.103	0.719
3	0.088	0.693
4	0.061	0.677
5 - low cost	0.044	0.743

Examining the adjustment in the EU market following the quota removal shows that there is a clear pattern of reallocation on both the extensive and intensive margin and the adjustment is related to the firm-level demand and fixed cost measures that we estimate with our structural model. High demand and low fixed cost firms account for a more substantial part of Chinese exports to the EU following the quota removal. Variation in marginal cost is only very weakly

correlated with the magnitude of net entry but is not systematically related to adjustment of exiting exporters on the intensive margin. One reason for the relatively weak correlation between export adjustment and marginal cost is that the overall variation in the marginal cost index is small compared to the variation in the demand and fixed cost indexes. There is less firm heterogeneity in this dimension and so other factors, including observable differences in marginal and heterogeneity in demand and fixed cost will play a larger role in generating profit differences across firms.

7   Summary and Conclusion

In this paper we utilize micro data on the export prices, quantities, and destinations of Chinese footwear producers to estimate a structural model of demand, pricing, and export market participation. The model allows us to quantify firm-level heterogeneity in demand, marginal cost and fixed costs and provides a way to combine them into a measure of a firm's profitability in each of seven regional export destinations. Estimation of the heterogeneity in firm demand parameters relies on across-firm differences in export market shares, controlling for firm prices, in the destination markets. The measure of marginal cost heterogeneity relies on differences in firm export prices, controlling for observable firm costs and markups, across destinations. Both factors play a role in determining the firm's profit in each export market and thus the decision to export. Estimation of the heterogeneity in the fixed cost of supplying a market exploits data variation in the number and pattern of export market destinations across firms.

To estimate the model we use panel data from 2002-2006 for a group of 738 Chinese firms that export footwear. The econometric methodology we utilize relies on Bayesian MCMC with Gibb's sampling for implementation. This allows us to both include a large number of unobserved firm components, three for each of our 738 firms, and to incorporate them consistently in both the linear and nonlinear equations in our model in a very tractable way.

The export price, quantity, and destination patterns across firms indicate a potentially important role for unobserved firm components that persist across destinations. Firms that export to many destinations also export to more difficult destinations and have higher average export quantities in each destination. This is consistent with persistent firm-level demand

heterogeneity. These same firms also have higher average export prices which suggests that the demand differences are costly to produce or maintain and is not consistent with low cost being the sole determinant of export success. The empirical results indicate substantial firm heterogeneity in demand, marginal cost and fixed cost dimensions. On the extensive margin, the fixed cost factor is the most important determinant of the number and pattern of export destinations. Once in the destination market, the demand and marginal costs factors are equally important in explaining export price variation across firms and destinations but the demand factor is approximately twice as important in explaining sales variation. We use the firm indexes to study the reallocation of export sales across Chinese producers in response to the removal of the quota on Chinese exports of footwear to the EU. We find that removal of the quota led to a substantial change in both the intensive and extensive margins of trade with the shift in composition toward firms with higher demand and lower fixed cost indexes. Differences in marginal costs play very little role in the reallocation of supply sources.

Overall, this paper represents a first step toward understanding how underlying firm heterogeneity on both the demand and production sides influences the long-run performance of Chinese manufacturing exporters. This paper demonstrates that firm parameters from demand, production cost, and fixed cost of the firm's activities can be retrieved from micro data on firm production and export transactions and that the firm parameters are useful in summarizing differences in firm export patterns across destination markets. The source of heterogeneity is potentially very important in understanding the ability of Chinese firms to compete in the future with other low-cost supplying countries. If there is limited scope for future cost improvements by Chinese producers, then the role of the demand component, both how it differs across firms and how it impacts profitability in a destination, will be critical to continued export expansion. The next step is to expand the framework we have developed here to allow these firm demand and cost components to vary over time and be altered by the firm's investments in R&D or physical capital so that firm export success or failure becomes a result of firm decisions to affect its productivity or demand for its products.

8   Appendix - Sampling Procedure

In this section we describe the process of sampling from the joint posterior distribution, equation (19), using Gibbs sampling over Θ_1, Θ_2, Θ_3, and $(\xi, c, \eta)_f$.

8.0.1   Sampling from the Posterior Distibution of Θ_1

The parameters in $\Theta_1 = (\alpha_d, \tau_{dt}, \xi_k, \gamma_w, \gamma_{dt}, \gamma_k, \rho_u, \rho_v, \Sigma_e)$ include all common parameters in the demand and pricing equations. Given draws of $(\xi, c, \eta)_1^{s-1} ... (\xi, c, \eta)_F^{s-1}$ from iteration $s-1$, we begin iteration s by sampling Θ_1^s. We rewrite the components of equation (16). First, using the demand curve (4) and serial correlation assumption on u_{kf}^{dt} define the time-differenced errors in the demand equation as:

$$
\begin{aligned}
e_1^t &= ln(s_{kf}^{dt}) - \xi_f^{s-1} - \xi_k + \alpha_d \ln p_{kf}^{dt} - \tau_{dt} - \rho_u(ln(s_{kf}^{dt-1}) - \xi_f^{s-1} - \xi_k + \alpha_d \ln p_{kf}^{dt-1} - \tau_{dt}) \quad (24) \\
&= e_1^t(\Theta_{11}, \xi_f^{s-1}, \rho_u)
\end{aligned}
$$

where Θ_{11} includes all the structural parameters in the demand curve. Similarly, for the pricing equation (6) define the time-differenced errors as:

$$
\begin{aligned}
e_2^t &= \ln p_{kf}^{dt} - \gamma_{dt} - \gamma_k - \gamma_w lnw_f^t - c_f - \rho_v(\ln p_{kf}^{dt-1} - \gamma_{dt-1} - \gamma_k - \gamma_w lnw_f^{t-1} - c_f) \quad (25) \\
&= e_2^t(\Theta_{12}, c_f^{s-1}, \rho_v)
\end{aligned}
$$

where Θ_{12} iincludes all the structural parameters in the pricing equation.

From equation (16), we can rewrite the joint density of u_{kf}^{dt} and v_{kf}^{dt} in terms of the data and parameters:

$$
h(u_{kf}^{dt}, v_{kf}^{dt} | u_{kf}^{dt-1}, v_{kf}^{dt-1}, \Theta_1, (\xi, c, \eta)_f^{s-1}) = \phi(e_1^t(\Theta_{11}, \xi_f^{s-1}, \rho_u), e_2^t(\Theta_{12}, c_f^{s-1}, \rho_v); \Sigma_e)
$$

where ϕ is the bivariate normal density. Equation (16) can now be expressed as:

$$
ld(D_f | \Theta_{11}, \Theta_{12}, \rho_u, \rho_v, \Sigma_e, (\xi, c, \eta)_f^{s-1}) = \prod_{d,k} \prod_t \phi(e_1^t, e_2^t; \Sigma_e) \quad (26)
$$

We specify the prior on each parameter in Θ_{11}, Θ_{12}, ρ_u, ρ_v as $N(0, 1000)$ and the prior on Σ_e as $IW(I, 2)$. The conditional posterior distribution of Θ_1 is:

$$\prod_f ld(D_f|\Theta_{11}, \Theta_{12}, \rho_u, \rho_v, \Sigma_e, (\xi, c, \eta)_f^{s-1}) \times P(\Theta_{11})P(\Theta_{12})P(\rho_v)P(\rho_u)P(\Sigma_e). \qquad (27)$$

We sample the subcomponents of Θ_1, again, using the Gibbs sampler. First, we sample Θ_{12}^s given values Θ_{11}^{s-1}, $\rho_v^{s-1}, \rho_u^{s-1}$, and Σ_e^{s-1} from the previous iteration. Given the linear form of the demand and pricing equation and the multivariate normal prior, the posterior distribution of Θ_{12}^s is multivariate normal and the mean and variance can be expressed in closed form (Rossi, Allenby, and McCulloch (2007), section 2.8) so it is simple to draw a value for Θ_{12}^s. Second, we sample Θ_{11}^s, given Θ_{12}^s, $\rho_v^{s-1}, \rho_u^{s-1}$, and Σ_e^{s-1}. At this point we deal with the endogeneity of price in the demand equation. Given Θ_{12}^s, $\rho_v^{s-1}, \rho_u^{s-1}$, and Σ_e^{s-1}, e_2^t in equation (25) can be constructed from the data, treated as known, and the joint distribution of $\phi(e_1^t, e_2^t; \Sigma_e)$ in equations (26) and (27) can be written as $\phi(e_1^t|e_2^t; \Sigma_e)$. The mean of the posterior distribution of Θ_{11}^s will have a closed form and depend upon e_2^t. Conditioning on e_2^t in this way, effectively controls for the source of endogeneity in the demand equation (Rossi, Allenby, and McCulloch,(2007), section 7.1). The final step in our use of the Gibbs sampler for Θ_1 involves sampling ρ_v^s, ρ_u^s, and Σ_e^s given Θ_{11}^s and Θ_{12}^s. Again, the mean and variance of the posterior distribution have a closed form given the conjugate normal prior on ρ_v^s, ρ_u^s and the inverted Wishart prior on Σ_e^s.

8.0.2 Sampling from the Posterior Distribution of Θ_2

The next step is to sample Θ_2, the parameters in the market participation equation (13). The priors are all $N(0, 1000)$. Using the likelihood for the participation condition, equation (15), the conditional posterior distribution is:

$$\prod_f lp(D_f|\Theta_2, (\xi, c, \eta)_f^{s-1}) \times P(\Theta_2).$$

The additional complication arising at this stage is that we cannot express the posterior mean and variance in closed form because of the nonlinearity of the participation equation. We could use Metropolis-Hastings accept/reject methodology to sample from the posterior

distribution. A faster alternative is to exploit the linearity of the latent variable equation $Y_f^{dt} = X_f^{dt}\Theta_2$ that underlies the participation decision. Rossi, Allenby, and McCulloch (2007, section 4.2) show that using the Gibbs sampler we can cycle between the parameter vector Θ_2 and the latent variable $Y_f^{dt} - \varepsilon_f^{dt}$. Given Θ_2^{s-1}, if $I_f^{dt} = 1$ (a firm exports) the latent variable $Y_f^{dt} - \varepsilon_f^{dt}$ is drawn from a normal distribution with mean $X_f^{dt}\Theta_2^{s-1}$ and variance equal to 1 and left-truncated at zero. If $I_f^{dt} = 0$, the latent variable is sampled from a normal with the same mean and variance and right-truncated at zero. Given the value of the latent variable, then the posterior distribution of Θ_2^s has a multivariate normal distribution with a closed form for the mean and variance.

8.0.3 Sampling from the Posterior Distribution of $(\xi, c, \eta)_f$

Given values Θ_1^s, Θ_2^s, and Θ_3^{s-1} we next sample $(\xi, c, \eta)_f^s$ for each firm. This step uses the data and model parameters from the demand, pricing, and export participation equations because $(\xi, c, \eta)_f$ enters into all these equations. The prior distribution $P((\xi, c, \eta)_f | \Theta_3)$ is assumed to be bivariate normal, $BVN(0, \Sigma_f^0)$. The conditional posterior distribution for these parameters is:

$$l(D_f | \Theta_1, \Theta_2, (\xi, c, \eta)_f) \times P((\xi, c, \eta)_f | \Theta_3).$$

At this stage we use Metropolis-Hastings accept/reject criteria firm-by-firm to sample from the posterior distribution.

8.0.4 Sampling from the Posterior Distribution of Θ_3

The final step samples Θ_3, the variance matrix for the ξ_f, c_f, η_f. It's prior $P(\Theta_3)$ is $IW(I, 3)$. This allows us to sample from the conditional posterior distribution:

$$\prod_f g((\xi, c, \eta)_f^s | \Theta_3) \times P(\Theta_3).$$

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