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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, 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.

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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

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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,

[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.

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 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 an empirical 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

[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 (2016) 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. Aw and Lee (forthcoming) measure firm-product-level differences in quality and productivity and show that their relative importance in determining firm export patterns depends on the degree of product differentiation in the market and the elasticity of production costs with respect to quality.

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 systematically 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 Gibbs 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.

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 Model of a Firm's Demand, Pricing, and Export Decisions

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 $i's$ utility function from purchasing product k from firm f is :

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

This specification allows for a variety-specific component δ_{kf}^{dt} that varies by destination market and year and an *iid* transitory component ϵ_i that captures all heterogeneity in preferences across importers.[3] Berry (1994) shows that, if ϵ_i 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:

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

[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. We will define this at the 4-digit product-group level. 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.

[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 fixed 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 4-digit 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

[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.

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 for each product and destination:

$$\begin{aligned} u_{kf}^{dt} &= \rho_u u_{kf}^{dt-1} + eu_{kf}^{dt} \\ v_{kf}^{dt} &= \rho_\nu v_{kf}^{dt-1} + ev_{kf}^{dt} \end{aligned} \tag{7}$$

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

$$e = (eu, ev) \sim N(0, \Sigma_e). \tag{8}$$

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}. Conditional on the permanent firm heterogeneity and product and destination dummies, the transitory demand and cost shocks are *iid* across destination and products. The pricing model implies that price in the demand curve, equation (4), is correlated with the firm demand component ξ_f and the transitory demand shock u_{kf}^{dt}. In estimation we use the firm-level cost shifters lnw_f^t as exogenous excluded variables. These include the log of the average manufacturing wages in the urban area and surrounding rural area, the log of land price for the city in which firm f is located, and the firm's capital stock.

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:

$$\ln r_{kf}^{dt} = \ln \Omega^{dt} + \ln r_k^d + \ln r^{dt}(\xi_f, c_f) \tag{9}$$

where

$$\begin{aligned} \ln \Omega^{dt} &= \ln(M^{dt}/V^{dt}) + \tau_{dt} + (1-\alpha_d)(\ln \mu_d + \gamma_{dt}) \\ \ln r_k^d &= \xi_k + (1-\alpha_d)\gamma_k \\ \ln r^{dt}(\xi_f, c_f) &= \xi_f + (1-\alpha_d)\left(\gamma_w lnw_f^t + c_f\right) + C_{uv} \end{aligned} \tag{10}$$

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} 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 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, (9), 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:

$$\ln \pi^{dt}(\xi_f, c_f; w_f^t, K_f) = \ln \left[\frac{1}{\alpha_d}\right] + \ln \Omega^{dt} + \ln \left[\sum_{k \in K_f} r_k^d\right] + \ln r^{dt}(\xi_f, c_f). \tag{11}$$

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.[6]

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

[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.

and aggregate state variables Ω^{dt} are assumed to evolve exogenously and the firm has rational expectation of future values.[7] The value function of a firm that is making the choice to export to a particular destination dt is:

$$V^{dt}(s_f^t, \Omega^{dt}, I_f^{dt-1}, \varepsilon_f^{dt}) = \max_{I_f^{dt} \epsilon (0,1)} \left[\pi^{dt}(s_f^t, \Omega^{dt}) - (1 - I_f^{dt-1})\kappa_s - (\mu_f + \varepsilon_f^{dt}) + V_e^{dt}(s_f^t, \Omega^{dt}), V_n^{dt}(s_f^t, \Omega^{dt}) \right] \tag{12}$$

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 if 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 (12):

$$Y_f^{dt} = \pi^{dt}(s_f^t, \Omega^{dt}) - (1 - I_f^{dt-1})\kappa_s - \mu_f + V_e^{dt}(s_f^t, \Omega^{dt}) - V_n^{dt}(s_f^t, \Omega^{dt}) \tag{13}$$

The latent payoff will depend on all three sources of firm heterogeneity and we will combine these into a single component that captures the combined effect of all three sources on the participation decision $\eta_f = \eta(\xi_f, c_f, \mu_f)$. We will refer to this as the firm export participation component. We parameterize the latent payoff as a function of the set of observable firm and market variables $X_f^{dt} = (w_f^t, K_f, \Omega^{dt})$ and the firm-specific factor η_f.

$$Y_f^{dt} = X_f^{dt}\psi + \delta I_f^{dt-1} + \eta_f$$

[7] Fully forward-looking firms will condition their participation decision on current transitory shocks u and v when these are serially correlated. In the participation model this requires integrating over the whole sequence of these shocks in addition to integrating over the firm demand and marginal cost components. We leave them out of firm's state variables for two reasons: first, these are idiosyncratic shocks at the firm-destination-product level, conditional on firm demand and cost heterogeneity. If these shocks are independent across products, then their impact on decision of entry at destination level will be attenuated. Second, a large fraction of these shocks could simply be measurement errors which by definition is not in firm's information set. We will take this possibility into account when we estimate the model.

The discrete export participation variable is defined as:

$$
\begin{aligned}
I_f^{dt} &= 1 \text{ if } X_f^{dt}\psi + \delta I_f^{dt-1} + \eta_f \geq \varepsilon_f^{dt} \\
&= 0 \text{ otherwise}
\end{aligned}
\tag{14}
$$

The third goal of our empirical model is to estimate the parameters of the firm's market participation decision ψ, δ and the firm export participation component η_f. Given the assumption that ε is distibuted $N(0,1)$, this equation is a probit model with a lagged dependent variable and a firm-specific random component.[8]

The presence of the lagged dependent variable in equation (14) leads to an initial conditions problem. We adopt Heckman's (1981) method for correcting for initial conditions. We model the firm's initial year in each destination, denoted $t = 0$, as a probit model which depends on the initial year factor prices, product mix and destination dummies X_f^{d0}, and the firm-specific participation component. The latter depends on a parameter ρ_η which allows the firm component in the initial year to be correlated with the component in the subsequent years.

$$
\begin{aligned}
I_f^{d0} &= 1 \text{ if } X_f^{d0}\psi_0 + \rho_\eta \eta_f \geq \varepsilon_f^{d0} \\
&= 0 \text{ otherwise}
\end{aligned}
\tag{15}
$$

This adds the parameter vector ψ_0 and ρ_η to the set of structural parameters to be estimated.[9]

The final element of the empirical model is the specification of the stochastic relationship between the three sources of firm heterogeneity, ξ_f, c_f, and η_f. We model the firm variables as:

$$
(\xi_f, c_f, \eta_f) \sim N(0, \Sigma_f) \tag{16}
$$

[8] 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 (14) 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 (14) is sufficient for our goal of estimating the distributions of ξ_f, c_f and η_f and conducting counterfactuals regarding the distribution of firm heterogeneity. The limitation of this approach is that we cannot conduct counterfactuals with respect to any parameters that enter the value function.

[9] Roberts and Tybout (1997) used this specification in their model of export market entry. Buchinsky, Fougère, Kramarz, and Tchernis (2010) used a similar specification when controlling for initial conditions in a worker's employment and mobility equations.

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.

3 Estimation

The goal of the empirical model is to estimate the structural parameters for demand and pricing, equations (4), (6), (7), and (8), export market participation, equations (14) and (15), and the distribution of the firm-specific components ξ_f, c_f, and η_f, equation (16). For each firm, our data consists of product mix K_f, a set of cost shifters lnw_f^t for each year, and export market participation dummies I_f^{dt} for each destination and year. Conditional on exporting to a destination in a year, $I_f^{dt} = 1$, we also observe prices lnp_{fk}^{dt} and market shares $\ln s_{fk}^{dt}$ for each product sold by firm f. To simplify the presentation of the likelihood function, we group the data and structural parameters in the following way. Define the full vector of participation dummies for firm f over all destination d and time t observations as I_f and denote the full vector of prices and market shares for the firm over all destinations, time, and products k as lnp_f and $\ln s_f$, respectively. Finally, denote the full set of data for firm f as D_f and the full set of data over all firms as D.

The structural parameters are grouped in a way that will facilitate estimation. Denote the set of demand and cost parameters that are common for all firms as $\Theta_1 = (\alpha_d, \tau_{dt}, \xi_k, \gamma_w, \gamma_{dt}, \gamma_k, \rho_u, \rho_\nu, \Sigma_e)$ and the participation parameters as $\Theta_2 = (\psi, \delta, \psi_0, \rho_\eta)$. 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.

Focusing first on the discrete destination decisions for firm f, the likelihood function for these data can be expressed using equations (14) and (15) as:

$$lp(I_f | \Theta_2, \eta_f) = \prod_d [\prod_{t=1}^{T} P(I_f^{dt} | \psi, \delta, \eta_f, X_f^{dt}, I_f^{dt-1})] P(I_f^{d0} | \psi_0, \rho_\eta, \eta_f, X_f^{d0}) \qquad (17)$$

The last term on the right-hand side of equation (17) represents the contribution of the initial year observations on the firm's export destinations I_f^{d0} to the likelihood.

The likelihood for the price and quantity observations of firm f is:

$$ld(lnp_f, \ln s_f|\Theta_1, \xi_f, c_f) = \prod_{d,k}[\prod_{t=\tau_0+1}^{\tau_1} h(u_{kf}^{dt}, v_{kf}^{dt}|u_{kf}^{dt-1}, v_{kf}^{dt-1}, \Theta_1, \xi_f, c_f)] \tag{18}$$

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.[10] Combining the participation, price, and quantity components, the likelihood for firm f (conditional on $(\xi, c, \eta)_f$) is then:

$$l(D_f|\Theta_1, \Theta_2, (\xi, c, \eta)_f) = lp(I_f|\Theta_2, \eta_f)ld(lnp_f, \ln s_f|\Theta_1, \xi_f, c_f) \tag{19}$$

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.

$$l(D_f|\Theta_1, \Theta_2, \Theta_3) = \int l(D_f|\Theta_1, \Theta_2, (\xi, c, \eta))g((\xi, c, \eta)|\Theta_3)d\xi dc d\eta \tag{20}$$

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.[11]

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:

$$P(\Theta_1, \Theta_2, \Theta_3, (\xi, c, \eta)_1, ..., (\xi, c, \eta)_F/D) \propto \left(\prod_f l(D_f|\Theta_1, \Theta_2, (\xi, c, \eta)_f)g((\xi, c, \eta)_f|\Theta_3))\right) P(\Theta_1, \Theta_2, \Theta_3) \tag{21}$$

[10] 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.

[11] 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 consistent as the number of observations per cell tends to infinity, even when the prior distribution of ξ, c, and η is misspecified. See Arellano and Bonhomme (2011).

Our goal is to characterize the posterior distribution, equation (21) numerically. This will allow us to describe the posterior distribution of both the Θ parameters and the demand, marginal 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. Details of the sampling strategy and the prior distributions are given in the appendix.

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. To identify firms that have production facilities, this data is important in our research to provide measures of total firm production and capital stocks. 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 dimensions both during 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. To be included in the sample, each firm must have at least one product/destination/year observation with exports. In the sample, in each destination/year between 20 and 50 percent of the firms are active. 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.[12]

[12] We conducted extensive interviews of approximately 30 owners of the firms in this sample during 2012 and 2013. These interviews confirm the important roles of both demand and cost components. Firm owners often describe one of the key demand factors as their existing foreign customer base. Typically foreign importers search for Chinese manufacturers and this process involves initial matching at either a large trade fair or by word of mouth. Chinese firms run display rooms and sometimes improve production line/labor standards to attract foreign customers to proceed with purchase. Meanwhile, cost efficiency is still very crucial for these firms to succeed among the fierce competition of other Chinese footwear producers.

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 product fk in market dt is defined as the sales of product fk 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. The fact that there are few observations with large market shares justifies our assumption of monopolistic competition in the firm's pricing decision.[13]

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

[13] 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.

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 markets and result in different export rates. They are captured in the theoretical model through the terms in $\ln \Omega^{dt}$ in equation (10) 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	0.544	0.533	0.495	0.493	0.494	0.512
Japan/Korea	0.410	0.384	0.377	0.380	0.375	0.385
Rest of Asia	0.362	0.413	0.428	0.430	0.410	0.408
Non EU Europe	0.365	0.359	0.356	0.374	0.390	0.369
Africa	0.234	0.275	0.282	0.351	0.348	0.298
Latin America	0.274	0.263	0.280	0.290	0.298	0.281
Australia/NZ	0.219	0.221	0.177	0.184	0.159	0.192

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)	0.209	0.323	0.095	0.123	0.033	0.040	0.063
2	(.182)	0.159	0.108	0.153	0.136	0.117	0.056	0.143
3	(.134)	0.130	0.099	0.172	0.136	0.168	0.119	0.080
4	(.112)	0.123	0.112	0.164	0.158	0.178	0.181	0.134
5	(.102)	0.143	0.112	0.149	0.184	0.182	0.220	0.170
6	(.061)	0.113	0.121	0.134	0.114	0.154	0.181	0.116
7	(.062)	0.123	0.125	0.134	0.149	0.168	0.203	0.295

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 $\bar{R}^2$ 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 destination-year combination, which will capture country-specific macro and industry conditions, accounts for just over 1 percent of the sample variation in prices and just over 5 percent in quantity. The product dimension accounts for 33.7 percent of the sample variation in log price and 10.7 percent in log quantity. Most importantly, the firm dimension accounts for the vast majority of the sample variation: 74.4 percent of the price variation and 39.8 percent of the quantity. Combining the firm and product dimensions together generates some additional explanatory power but the improvement is modest. 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

$\bar{R}^2$ from OLS regressions

Categories of Controls	log price	log quantity
Destination*Year (35 categories)	0.014	0.051
Four-Digit Product (3 categories)	0.337	0.107
Firm (738 firms)	0.744	0.398
Destination*Year, Product	0.344	0.145
Destination*Year, Product, Firm	0.809	0.448
Destination*Year, Product*Firm	0.837	0.493

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, although not monotonically, 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	0.020 (0.024)	0.109 (0.086)
3	0.133 (0.025)	-0.172 (0.088)
4	0.082 (0.025)	0.173 (0.088)
5	0.107 (0.024)	0.145 (0.084)
6	0.172 (0.025)	0.507 (0.088)
7	0.009 (0.022)	0.281 (0.079)
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 an empirical 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 the system of equations using the Bayesian MCMC methodology and the entries are the mean and standard deviations of the posterior draws from the Markov chain. Each column uses a different set of instrumental variables to control for the endogeneity of the output price.[14] 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.[15] These system estimates recognize and account for the endogenous selection of the export markets that the firm participates in. For comparison, the final two columns report OLS and IV estimates of just the demand equation, without specifying the endogenous selection of export markets. To be consistent with the model assumption of ξ_f, we use a random effect IV specification, and just report the results for the IV1 set of instruments.

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

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

[15] 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.

from textile shoes, relative to rubber shoes.

Table 6 - Demand Curve Parameter Estimates (standard error)					
	Bayesian System of Equations			Demand Equation Only	
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 does not account for the endogenous selection of export markets. It produces estimates of $-\alpha_d$ that are more elastic than OLS but, in most cases, are less elastic than the system estimates and have much larger standard errors.[16]

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, and highly significant.[17] When

[16] In Monte Carlo experiments, reported in the supplementary appendix, we find a similar ranking of demand elasticities with OLS smaller than IV and both smaller than the IV system estimates. Correcting for the endogenous selection of markets is important when estimating the demand and pricing equations. A similar observation is made by Ciliberto, Murry, and Tamer (2016) in a model of airline pricing where firms endogenously choose the markets to serve.

[17] We also conducted a likelihood ratio test for the combination of all cost shifters. For our benchmark specification (IV2), the test statistics is 170.6, so it strongly rejects the nested model where all cost shifters are zero.

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.[18] The product 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.

Table 7 - Pricing Equation Parameter Estimates			
	Bayesian System of Equations		
	IV1	IV2	IV3
$ln(urbanwage)_{ft}$	0.200 (0.022)	0.180 (0.024)	0.175 (0.024)
$ln(ruralwage)_{ft}$	0.041 (0.010)	0.038 (0.010)	0.039 (0.010)
$ln(landrentalprice)_{ft}$		0.014 (0.007)	0.011 (0.007)
$ln(capital)_{ft}$			0.005 (0.002)
Product Group Dummies (γ_k)			
Leather Shoes	0.597 (0.032)	0.596 (0.031)	0.596 (0.031)
Textile Shoes	-0.054 (0.037)	-0.054 (0.036)	-0.055 (0.036)
Transitory Shocks (ρ_u, ρ_v, Σ_e)			
ρ_u	0.640 (0.009)	0.640 (0.009)	0.640 (0.009)
ρ_v	0.671 (0.011)	0.669 (0.011)	0.669 (0.011)
$Var(eu)$	2.107 (0.114)	2.134 (0.115)	2.096 (0.114)
$Var(ev)$	0.084 (0.002)	0.084 (0.002)	0.084 (0.002)
$Cov(eu, ev)$	0.169 (0.026)	0.177 (0.026)	0.167 (0.028)
The model includes a full set of destination*year dummies			

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

[18] 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.

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.

5.3 Market Participation

The third component of our empirical model is the probability of exporting, equation (14) and equation (15), 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 (10), 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 the firm component η_f in the initial and later years is ρ_η and 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
$ln(urbanwage)_{ft}$	-0.458 (0.077)	-0.448 (0.081)	-0.433(0.081)
$ln(ruralwage)_{ft}$	-0.081 (0.041)	-0.076 (0.041)	-0.071 (0.042)
$ln(landrentalprice)_{ft}$		-0.007 (0.028)	-0.004 (0.028)
$ln(capital)_{ft}$			-0.005 (0.013)
product mix $\sum_{k\in K_f} r_k^d$	0.367 (0.036)	0.366 (0.036)	0.371 (0.037)
past participation I_f^{dt-1}	2.071 (0.030)	2.069 (0.029)	2.080 (0.030)
Initial Conditions			
$ln(urbanwage)_{f0}$	-0.907 (0.156)	-0.859 (0.159)	-0.717 (0.148)
$ln(ruralwage)_{f0}$	-0.516 (0.131)	-0.441 (0.136)	-0.512 (0.130)
$ln(landrentalprice)_{f0}$		-0.162 (0.063)	-0.109 (0.059)
$ln(capital)_{f0}$			0.139 (0.022)
product mix $\sum_{k\in K_f} r_k^d$	0.571 (0.063)	0.580 (0.065)	0.594 (0.059)
ρ_η	1.327 (0.319)	1.462 (0.374)	1.135 (0.253)
The model includes a full set of destination*year dummies			

5.4 Goodness of Fit

Table 9 provides goodness of fit measures for the estimated market share, pricing, and participation equations.[19] We simulate the model 1000 times and report the mean and standard deviation of moments of the distributions. In the upper panel, we compare the distribution of log price and log normalized market share predicted by the model versus the data. The distributions of both price and market share match the data well. For almost all percentiles, the simulated moments are close to their data counterparts. The only exception is the 10th percentile, where the model under-predicts the dispersion of prices and slightly over-predicts the dispersion of market shares.[20] In the lower panel, we compare the patterns of exporting between the simulations and the data. On the left side, we show that, conditional on ex-

[19] We use our model estimates to simulate the three unobserved permanent heterogeneity components ξ_f, c_f, and η_f for each of the 738 firms in our data. We then forward-simulate their demand, price, and participation decisions for each of the seven destinations, taking their product mix as given. Since we allow firms to endogenously choose to enter or stay out of each destination, the observed price and market share distributions in our simulation also reflect the selection of firms into export activity.

[20] The model also replicates the small negative correlation between log market share and log price, -0.261 in the simulation and -0.312 in the data, despite the fact that the estimated price elasticities are around -3.0. The positive correlations of the firm demand and cost components, ξ_f and c_f, and the transitory shocks, u_{kf}^{dt} and v_{kf}^{dt}, will act to reduce the negative correlation between price and market share.

porting, the fraction of firms exporting to each of the seven destinations is well-explained by the model simulations. The destination-specific market effect plays an important role in this pattern. On the right side, we report the fraction of firms exporting to one to seven destination in year 2005. Overall, the model does relatively well in matching these moments. The fraction of firms exporting declines monotonically with the number of destinations. Similar to the data, the simulations show that the majority of firms export to one or two destinations, although we slightly over-predict two destination firms. On the higher end, though, the model slightly underpredicts the number of firms exporting to five or more destinations.[21]

Table 9: Goodness of Fit

	Model Simulation		Data		Model Simulation		Data
Percentile	Mean	St. Dev			Mean	St. Dev	
	log Price				log Market Share		
$P10$	0.095	0.036	0.033	$P10$	-8.412	0.084	-8.243
$P25$	0.551	0.029	0.557	$P25$	-6.938	0.072	-6.791
$P50$	1.064	0.027	1.117	$P50$	-5.293	0.068	-5.285
$P75$	1.583	0.029	1.581	$P75$	-3.643	0.073	-3.818
$P90$	2.054	0.037	2.061	$P90$	-2.150	0.088	-2.500
	Export Proportion by Destination				Number of Destinations		
US/Canada	0.505	0.019	0.512	$n = 1$	0.307	0.018	0.348
Japan/Korea	0.380	0.019	0.385	$n = 2$	0.255	0.018	0.182
Rest of Asia	0.172	0.015	0.192	$n = 3$	0.190	0.016	0.134
Non EU Europe	0.416	0.020	0.408	$n = 4$	0.127	0.013	0.112
Africa	0.354	0.019	0.369	$n = 5$	0.075	0.011	0.102
Latin America	0.305	0.018	0.298	$n = 6$	0.035	0.007	0.061
Australia/NZ	0.265	0.018	0.281	$n = 7$	0.011	0.004	0.062

5.5 Assessing the Contribution of Firm Heterogeneity

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

[21] It can be due to the fact that the Bayesian shrinkage estimator does well in identifying the overall distribution of unobserved heterogeneities, but is less successful in capturing the far right tail of demand and the far left tail of costs.

distribution of the firm components. Table 10 reports the posterior mean and standard deviation of the variance matrix of the firm effects Σ_f.

Table 10 - 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 side. 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 (14) and (15) are normalized by the variance of the shock ε_f^{dt}. The final three parameters reported in Table 10 are the covariances between the three firm components. The covariance (correlation) between the demand and cost components is 0.795 (0.709) , 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 weakly positively correlated with both the demand component, covariance (correlation) of 0.099 (0.140), and the cost component, covariance (correlation) of 0.012 (0.056).

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.[22]

$$\begin{aligned} \xi_f &= \xi_f \\ c_f &= a_1 \xi_f + \omega_f. \\ \eta_f &= a_2 \xi_f + a_3 c_f - \mu_f \end{aligned} \tag{22}$$

There is a one-to-one mapping from the six elements of Σ_f in Table 10 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 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 (22). The log market share components are:

$$\begin{aligned} D_\xi &= V((1-\alpha_d a_1)\xi_f)/V(\ln(s_{kf}^{dt})) \\ D_\omega &= V(-\alpha_d \omega_f)/V(\ln(s_{kf}^{dt})) \end{aligned} \tag{23}$$

The log market price components are:

$$\begin{aligned} P_\xi &= V(a_1 \xi_f)/V(\ln p_{kf}^{dt}) \\ P_\omega &= V(\omega_f)/V(\ln p_{kf}^{dt}) \end{aligned} \tag{24}$$

[22] 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:

$$
\begin{aligned}
R_\xi &= V(1+(1-\alpha_d)a_1)\xi_f)/V(\ln r_{kf}^{dt}) \qquad (25)\\
R_\omega &= V((1-\alpha_d)\omega_f)/V(\ln r_{kf}^{dt})
\end{aligned}
$$

The six components are reported in Table 11. 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 11: 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 can be seen by calculating how the probability of exporting changes with variation in each component. Table 12 reports these contributions.

Table 12: 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.

We also use the model to simulate how changes in magnitude and source of firm heterogeneity affect the distribution of prices and quantities and the export participation patterns of firms. These simulations use the full model and thus account for the endogenous choice of export destinations. We simulate three counterfactural environments. The first case simulates how the price and quantity distributions are affected if the variance of the demand component $V(\xi_f)$ is reduced by 50 percent, from 3.687 to 1.844. This directly reduces the dispersion in firm demand. The second case simulates the effect of a reduction in firm cost heterogeneity. By setting $a_1 = 0$ in equation (22), this reduces the dispersion in firm cost by removing the cost disadvantage faced by high-demand firms. In this case $V(c_f) = V(\omega_f)$ which, given the parameter estimates, is a 63 percent reduction in $V(c_f)$, from 0.341 to 0.127. The third case simulates a reduction in the variance of the fixed cost component $V(\mu_f)$ by 50 percent to 0.064. The results of the three simulations on the price and quantity distributions are reported in Table 13.

Table 13: Effect of Reductions in Firm Heterogeneity

	Benchmark	Counterfactual Simulation		
		$V(\xi_f)$ reduction	$a_1 = 0$	$V(\mu_f)$ reduction
		Distribution of log Price		
Median	1.064	1.051	1.038	1.066
$(P90 - P10)/P50$	1.841	1.722	1.588	1.835
		Distribution of log Market Share		
Median	-5.293	-5.318	-5.176	-5.297
$\lvert(P90 - P10)/P50\rvert$	1.183	1.150	1.494	1.184
		Frequency of the Number of Destination Markets		
$n \leq 3$	0.752	0.752	0.750	0.808
$n \geq 4$	0.248	0.248	0.250	0.192
		Regression Coefficient log Price		
β_{23}	0.006	-0.008	-0.021	0.005
β_{47}	0.013	-0.017	-0.046	0.014
		Regression Coefficient log Market Share		
β_{23}	0.104	0.082	0.220	0.128
β_{47}	0.238	0.190	0.523	0.286

The second column summarizes the distribution of log price, log market share, and the number of destination markets from the benchmark simulation reported in Table 9. The third column shows how these distributions shift when the heterogeneity in firm demand is reduced. In this case, the median price falls approximately 1 percent, from 1.064 to 1.051, and the dispersion of prices is also reduced. The median and the dispersion in log market share are also reduced but the changes are very modest. The market share changes reflect the changes in the distribution of ξ_f but also the change in the distribution of prices. The former will reduce the market share variation, while the latter will put more weight on the remaining differences in ξ_f because the price differences are not as large. Finally, the bottom panel shows that there is no change in the proportion of firms that sell in three or few markets or four or more markets. In the second set of simulations $a_1 = 0$, which removes the cost disadvantage of high demand firms. In this case firm demand heterogeneity is a source of horizontal, rather than vertical, differentiation. In this case, the median price falls from 1.064 to 1.036 but the dominant effect is that the price distribution narrows substantially. On the quantity side, market share dispersion rises substantially, with the market share of the smaller firms declining and the market share of the larger firms rising. By reducing the cost heterogeneity and resulting price dispersion, the market share dispersion more closely reflects the heterogeneity in ξ_f. There is no effect on the pattern of market participation by the firms. The final simulation reduces the dispersion in the fixed cost $V(\mu_f)$. There is no effect on the distribution of prices or market shares but there is a clear reduction in the number of destination markets. The frequency of firms exporting to three or fewer markets rises from 0.752 to 0.808. Although not reported in the table, there is an increase in the proportion of firms exporting to one, two, and three destinations and a decline for each of the four through seven destinations. Consistent with the pattern of intensive and extensive margin heterogeneity reported in Tables 11 and 12, the price and market share patterns are driven by heterogeneity in firm demand and cost while the pattern of export market participation is driven primarily by heterogeneity in the fixed costs of serving a market.

The bottom two panels in Table 13 summarize the relationship between price, market share, and the number of destinations in each of the simulated environments. To summarize the patterns we estimate regressions of $\ln Y_{it} = \beta_0 + \beta_t + \beta_k + \beta_{23} D23_{it} + \beta_{47} D47_{it} + \epsilon_{it}$ where Y_{it} is log price or log market share, β_t and β_k are year and product effects, $D23_{it}$ is a dummy equal to one if the firm exports to $n = 2, 3$ destinations and $D47_{it}$ is a dummy equal to one if the firm exports to $n = 4, 5, 6, 7$ destinations. The base group are the firms that export to one destination. In the benchmark case the β_{23} and β_{47} coefficents imply that firms that export to 2-3 and 4-7 destinations have log prices that are 0.006 higher and 0.013 higher than firms that export to one destination. Similarly they have log market shares that are 0.104 and 0.238 higher than firms that export to one destination. Firms that export to more destinations have higher market shares and higher prices in those destinations.

As the underlying degree of firm heterogeneity changes there are systematic changes in this relationship. When the $V(\xi_f)$ is reduced, the prices of the multi-destination exporters fall, on average, compared to the prices of the single destination exporters, while they rose in the base case. The market shares continue to be larger for the multi-destination exporters, coefficients of 0.082 and 0.190, but the differences are not as substantial as in the base case. Overall, relative to the base case, a reduction in firm demand heterogeneity results in prices that fall and market shares that become more similar among the exporting firms. These changes are larger in magnitude for the firms that export to four or more destinations indicating that, under this scenario, these exporters lose some of the unique attribute that gave them higher prices and larger market shares. The response to a reduction in cost heterogeneity, $\alpha_1 = 0$, is very different. In this case, prices fall substantially for the multi-destination exporters, coefficients of -0.021 and -0.046, and the market shares of these firms increase substantially. As with the previous case, the changes are more substantial for the exporters selling in four or more destinations. Under this scenario, cost heterogeneity is reduced by removing the cost disadvantage faced by high demand firms and this leads these diversified exporters to gain lower prices more and gain market share relative to the less-diversified exporters. The final experiment reduces the variance of the fixed cost $V(\mu_f)$. This removes some of the advantage that will lead low fixed-cost firms to export to many destinations. This has no effect on the price premium charged by the multiple-destination exporters when compared with the base case and results in a small increase in market shares relative to the base case. In this case variation in the demand side factor will play a more prominent role in the decision to be in multiple markets and this is reflected in the slight increase in the market share of the multi-destination sellers.[23]

To summarize, this section provides estimates of structural demand, pricing and export participation equations for Chinese footwear exporting firms across seven destination markets. The 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

[23] The first two counterfactuals will change the inclusive value of our sample varieties. However, since our sample firms account for a relatively small market share, 6-11% across markets. The change in the total inclusive value of all varieties V^{dt} is small. When we adjust for this change, it has little impact on normalized market shares and simulated counterfactual results.

marginal cost component but both play a significant role in generating differences in firm price and output 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. Model simulations reinforce the conclusion that demand and cost heterogeneity is important in generating price and output differences while fixed cost heterogeneity is important in generating the pattern of export market participation. 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 play 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 when 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. 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.

Khandelwal, Schott, and Wei (2013) study the quota on Chinese apparel exports under the multi-fiber agreement. They find that the allocation of the export licenses across Chinese firms was a major source of inefficiency. The quota licenses were not allocated in a way that reflected underlying differences in revenue productivity among exporters. Removal of the quota resulted in a substantial expansion of apparel exporters with approximatlely three-fourths of the increase due to reallocation of market shares toward more productive firms and one-quarter to the elimination of the actual quota. We provide additional evidence on the first channel through a slightly different mechanism which focuses on the choice of importing firms by the EU buyers before and after the quota.

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 14 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.[24]

Table 14 - 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 15 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

[24]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.

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 15: Source of Export Expansion by Year, Destination

	2002	2003	2004	2005	2006
Extensive Margin (Prop. firms exporting to destination)					
EU	0.355	0.440	0.477	0.536	0.541
US/Canada	0.498	0.560	0.509	0.536	0.536
Japan/Korea	0.420	0.432	0.440	0.440	0.432
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 15 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, marginal cost, and fixed cost indexes. In Table 16 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 17, 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. Table 16 reports turnover patterns for each bin based on averages of all the simulations.

Table 16: 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 16 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 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 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.[25]

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. Ta-

[25]Standard deviations of these summary statistics are reported in the supplementary appendix. All of the differences in entry and exit rates between high-low demand and cost categories are significant at the 5% level.

ble 17 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 reallocated toward firms with the lowest marginal cost indexes.

Table 17 - 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 empirical 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 cost and heterogeneity in demand and fixed cost will play a larger role in generating profit differences across firms.

The last two tables show a clear pattern of adjustment across the five demand categories, with high demand firms expanding and surviving in the EU following the quota removal. To assess whether this represents a reallocation due to the quota removal or just a general trend in the recomposition of exporting firms reflecting differences in their underlying ξ_f, we compare the change in the total exports by demand category in the EU with the change for China's two most important trading partners, Japan/Korea and the US. Table 18 reports the predicted growth rate of total export volume by firms in each of the five demand categories between 2002-2006 for the three destinations.

Table 18: Growth Rate of Total Export Volume 2002-2006 by Demand Category

	EU	Jap/Kor	U.S.	Difference (95% CI)	
Demand ξ_f				EU vs. Jap/Kor	EU vs. US
1 - low demand	-0.088	-0.042	-0.055	-0.046 (-0.047, -0.045)	-0.033 (-0.034, -0.033)
2	-0.030	-0.034	-0.008	0.004 (0.003, 0.005)	-0.023 (-0.024, -0.022)
3	0.020	-0.009	0.017	0.029 (0.028, 0.031)	0.003 (0.002, 0.004)
4	0.087	0.020	0.009	0.067 (0.066, 0.068)	0.079 (0.078, 0.080)
5 - high demand	0.011	0.066	0.036	-0.055 (-0.056, -0.054)	-0.026 (-0.026, -0.025)

The second, third, and fourth columns show the growth in export volume to each of the three destinations. It is clear that total exports by firms in the lowest two demand categories fell in all three destinations and in the highest two categories rose in all three destinations. There was a shift toward a higher volume of exports originating from high ξ_f producers in all three destinations. The last two columns of the table report the growth rate in the EU minus the growth rate in each of the other destinations. The numbers in the first row imply that the lowest ξ_f firms contracted exports more to the EU than to either of the other two destinations.

The category 2, 3, and 4 firms all expanded more in the EU than in Japan/Korea and the expansion was larger as the demand category increased. For example, exports in category 4 increased 6.7 percent more in the EU than in Japan/Korea. A similar greater reallocation away from the low demand categories 1 and 2 and toward category 4 is also seen when comparing the EU and the US. All of this is consistent with the EU quota removal leading to a more substantial reallocation toward high demand firms. The pattern breaks down with the highest demand category. In this case, while these firms expand total exports in all three countries the growth in exports is smaller in the EU than in the other two destinations. This can be traced to the relatively low growth rate in exports to the EU by firms in the highest demand category, 1.1 percent. While the difference estimates provide some evidence that the quota removal led to a differential impact on the demand sources exporting to the EU, the pattern is not consistent with this for the group of firms with the highest levels of ξ_f.

7 Summary and Conclusion

In this paper we utilize micro data on the export prices, quantities, and destinations of Chinese footwear producers to estimate an empirical 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 Gibbs 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 (21), using Gibbs sampling over Θ_1, Θ_2, Θ_3, and $(\xi, c, \eta)_f$.

8.0.1 Sampling from the Posterior Distribution 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 the parameters in the demand and pricing equations that are common to all firms. 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 (18). First, using the demand curve (4) and serial correlation assumption on u_{kf}^{dt} (7) define the time-differenced errors in the demand equation as:

$$\begin{aligned} e_1^t &= ln(s_{kf}^{dt}) - \xi_f^{s-1} - \xi_k + \alpha_d \ln p_{kf}^{dt} - \tau_{dt} - \rho_u(ln(s_{kf}^{dt-1}) - \xi_f^{s-1} - \xi_k + \alpha_d \ln p_{kf}^{dt-1} - \tau_{dt-1}) \\ &= e_1^t(\Theta_{11}, \xi_f^{s-1}, \rho_u) \end{aligned} \tag{26}$$

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

$$\begin{aligned} e_2^t &= \ln p_{kf}^{dt} - \gamma_{dt} - \gamma_k - \gamma_w lnw_f^t - c_f - \rho_v(\ln p_{kf}^{dt-1} - \gamma_{dt-1} - \gamma_k - \gamma_w lnw_f^{t-1} - c_f) \\ &= e_2^t(\Theta_{12}, c_f^{s-1}, \rho_v) \end{aligned} \tag{27}$$

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

From equation (18), we can rewrite the joint density of u_{kf}^{dt} andv_{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 (18) can now be expressed as:

$$ld(D_f|\Theta_{11}, \Theta_{12}, \rho_u, \rho_v, \Sigma_e, (\xi, c, \eta)_f^{s-1}) = \prod_{d,k} \prod_t \phi(e_1^t, e_2^t; \Sigma_e) \tag{28}$$

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:

$$\prod_f ld(D_f|\Theta_{11}, \Theta_{12}, \rho_u, \rho_v, \Sigma_e, (\xi, c, \eta)_f^{s-1}) \times P(\Theta_{11})P(\Theta_{12})P(\rho_v)P(\rho_u)P(\Sigma_e). \tag{29}$$

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 (27) 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 (28) and (29) 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 equations (14) and (15). The priors are all $N(0, 1000)$. Using the likelihood for the participation condition, equation (17), 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, 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 multivariate normal, $N(0, \Sigma_f^0)$. 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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