

Sizing Up Market Failures in Export Pioneering Activities: Some Structural Estimation Evidence *

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Abstract

The paper aims to provide a first structural-estimation-based assessment of an influential hypothesis in the international trade literature that export pioneering activities are prone to market failure. It points out that the existence of positive discovery costs incurred by an export pioneer and the existence of spillover from the pioneer to follower firms are necessary but not sufficient conditions for market failure. Market failure also requires two inequalities to hold simultaneously: the discovery cost is greater than any individual firm's expected profit but smaller than the sum of all potential exporters' expected profits. Neither inequality has to hold necessarily in the data. We use structurally estimated parameters, based on the micro customs data of Chinese electronics exports, to assess the empirical plausibility of market failure. Even though there is evidence of positive discovery cost and spillovers, we find that market failure is not a high likelihood event in practice.

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1 Introduction

Using a structural estimation approach, this paper aims to gauge the empirical plausibility of an influential hypothesis that export pioneering activities are prone to market failure.

Arrow (1962) may be the first to formally model the notion that with knowledge spillover from one firm's investment to other firms, market failure may occur if all firms under-invest in these activities. Market failure can be avoided if the newly discovered knowledge can be patented so that the pioneering firm can capture the full value of its effort. In international trade context, some have argued that market failure is particularly likely in export pioneering activities. When a firm exports a product to a new market, it has to pay a cost of discovery to learn about local taste, local regulation, and the appropriate amount of "tinkering" that may be needed to make the sale possible. If this new knowledge can be costlessly utilized by subsequent exporters to the same market, there is a gap between the social value of the first discovery and the private value to the pioneering exporter. Because the knowledge about a new export market is hard to patent, firms collectively may engage in less export pioneering activities than socially optimal. This type of market failure has been emphasized in the theoretical models by Hoff (1997) and Hausmann and Rodrik (2003) as a possible explanation for why many developing countries fail to convert their potential comparative advantage into actual exports. Since new exports can bring benefits to accelerate growth (Lucas, 1993; Kehoe and Ruhl, 2009; and Amsden, 1992, insufficient amount of export pioneering activities and under-exporting may contribute to economic under-development. Many have cited this possibility as a basis for arguing government intervention, in the form of subsidizing export discovery activities (Hausmann and Rodrik, 2003; Rodrik, 2004). This hypothesis is very influential. For example, the Hausmann and Rodrik (2003) paper has 1095 citations by Google Scholar count.

Several recent empirical papers provide support for various elements of the market failure hypothesis. Freund and Pierole (2010) examined the case of Peruvian exports of nontraditional agricultural products (e.g., asparagus) which didn't grow locally and were not part of the traditional local diet. Ex post, Peru proves to be good at producing and exporting these products. But the country did not do so and probably would not do so except for some serendipitous government interventions via a US foreign aid program. The case study supports the notion that a country's latent comparative advantage needs to be discov-

ered and the discovery is costly. Artopoulos, Friel, and Hallak (2011) study the beginning of Argentinian exports of wine, boats, TV programs and furniture to the US market, and suggest that, at least in these four cases, the start of exports is somewhat random, and there is knowledge spillover from the pioneering exporters to follower firms. Of course, for each of these four cases, because the export pioneering activities did take place, market failure was avoided. One may be tempted to think that market failure can happen in many other cases when the discovery of a new market is costly and there is knowledge spillover from the pioneering exporter to follower firms.

However, the existence of costly discovery and positive externality do not automatically imply the existence of market failure and a need for government intervention. Market failure in export pioneering activities also requires two inequalities to be satisfied simultaneously. First, the discovery cost for entering a new market has to be smaller than the sum of the expected profits of all potential exporters in that market. Otherwise, even a social planner would not want to pay the cost to discover that new market. Second, the discovery cost has to be greater than the expected profit of any individual firm. Otherwise, some firm will find it profitable to unilaterally pay the discovery cost in spite of its inability to capture all the value of the discovery, and the knowledge spillover will take place anyway. Since no presumption exists in economic theory that either of the two inequalities has to hold, one has to assess the likelihood of market failure based on the empirical evidence on these inequalities. As far as we know, there has been no empirical work that takes the approach of assessing both inequalities simultaneously. Hence, we are not yet able to judge if market failure in export pioneering activities is a high probability event.

In this paper, we employ a structural estimation approach to study this question, using Chinese export data at the firm-product-destination level for 21 HS 6-digit electronics products (e.g., cameras, radios, radars, television sets). We first use annual export data during 1996-1999 from the Comtrade database to identify product destination pairs that China did not export prior to 2000, then use monthly Chinese customs data to capture all new market explorations during 2000-2003, and track the export activities of both pioneers and follower firms at the product-destination level by month throughout 2000-2006. A structural model and a maximum likelihood estimation procedure (modified from an approach developed by Roberts et al., 2012) allow us to estimate a set of structural parameters including the discovery costs (which vary by sector and destination), the strength of first mover advantage, and other demand and

cost parameters. Our identification comes from observing if and when a new market is explored, who the pioneers are, who the follower firms are, and how their respective export volumes and prices (unit export values) evolve over the sample period. Armed with these structural parameters, we make assessments on the likelihood that market failure occurs.

To preview the main results, we find positive costs of discovery, evidence of knowledge spillover from export pioneers to follower firms, and evidence of positive first mover advantage enjoyed by the pioneering firms that decays over time. Most importantly, using the estimated structural parameters, we discover that the probability of market failure is generally not very high. The inference remains the same in a number of extensions we have explored.

Note that we can distinguish between two kinds of export discovery activities. The first is to take an existing product to brand new destinations, and the second is to export a brand-new product that has never before been exported by the country. Our estimation focuses on the first type of discoveries. Therefore, it is still possible that the likelihood of market failure is higher for the second type of export pioneering activities. Assessing the second type of discoveries presents new challenges. If a product is not being exported to any destination, it could be either because the country has no comparative advantage in the product or because market failure has prevented firms from undertaking the export pioneering exploration. We will later provide some calculations that suggest that the second type of market failure is not a high probability event either.

While our paper shares some common features with the existing literature by allowing for both discovery cost and knowledge spillover, it also differs in three important ways. First, we introduce first mover advantage (FMA) and customer loyalty to the model. They are likely to reduce the likelihood of market failure. (Note that we allow for but do not impose either FMA or customer loyalty.) Second, we use structural estimation to uncover the value of parameters rather than reduced form regressions or case studies. Third, we provide the first-ever assessment of the likelihood of market failf (the percentage of product x destination pairs for which both inequalities hold). Our conclusion is also different from the existing literature - our results suggest that market failures are not a high probability event in the context of export pioneering activities in spite of its theoretical plausibility.

The rest of this paper is organized as follows. In Section 2, we review a larger body of the literature and comment on the contribution of our paper to

the literature. In Section 3, we set up a structural model of a firm’s demand and cost equations and optimization problem. We pay special attention to when a firm decides to be an export pioneer in an unexplored market, and when a firm decides to be a follower exporter when the market has already been explored. In Section 4, we explain the procedure and techniques we use to estimate this non-linear problem with a large number of parameters. In Section 5, we introduce and summarize the Chinese export data at the firm-product-destination level over our sample period, highlighting a few salient features that are particularly relevant for our research question. In Section 6, we present our baseline estimation results, including parameters for discovery costs and first mover advantages. Using the structural parameter estimates, we contrast the central planner’s solution and the decentralized equilibrium and provide an assessment of the probability of market failure in export pioneering activities. In Section 7, discuss a number of extensions and robustness checks. Finally, in section 8, we provide concluding remarks and point to directions for future research.

2 Placing the Paper in Broader Literatures

2.1 Informational barriers in trade in theory and empirics

In terms of theoretical work on the subject, while Hoff (1997) predates Hausmann and Rodrik (2003), the latter has played a more influential role in calling attention to the possibility that export pioneering activities are prone to market failure, as suggested by the latter’s higher citation count (of over 1000). Wagner and Zahler (2013) proposes a model that features a substantial role for random shocks in deciding which firm will become a pioneer. In other words, in their model, it is not necessarily the most productive firm that will become a pioneer. They argue that this assumption is supported by the firm-product level data on Chilean exports. This is in contrast with Melitz (2003) model (also Freund and Pierole, 2010) in which firm productivity is the key determinant of whether a firm would export or not and how much to export. In the model we will present, heterogeneous productivity across firms will give the more productive firms an edge in the export decision, other things equal. However, other things are not held equal in our model. In particular, all firms are assumed to face a random firm-product-destination specific fixed entry cost, drawn from a common distribution. The latter assumption is motivated by the work of Wagner and Zahler.

Thus, a less productive firm with a lucky draw of a low fixed entry cost could enter a new destination ahead of an otherwise more productive firm but with an unlucky draw of a high fixed entry cost. Our data turn out to be consistent with this assumption as well.

None of the theoretical papers formally states that the existence of discovery cost and spillover are only the necessary but not sufficient conditions for market failures. None of the theoretical papers proves that either of the two inequalities has to hold. This suggests whether the two inequalities hold or not needs to be resolved empirically.

We have already noted that several empirical papers cite the theoretical papers above and proceed to provide empirical support for parts of the story. Prominent empirical papers include Freund and Pierole (2010) and Artopoulos, Friel, and Hallak (2011). The key takeaway from these analytical case studies is that the discovery of a new market is costly. Just because a country can later show to have a comparative advantage in producing and exporting a particular product does not mean that firms from this country on their own would produce such a product in a free market economy. In addition to showing that a pioneer firm becomes a pioneer often for random reasons (e.g., a chance visit in the US), Artopoulos, Friel, and Hallak (2011) and Wagner and Zahler (2013) also document the existence of spillover from a pioneer to other firms. In their data, once a pioneer becomes successful, imitators tend to emerge relatively quickly. Fernandez and Tang (2014) provide both a model and evidence that exporting firms learn about a foreign market from the successes and failures of other firms. Entry rate of new exporters in a market is positively correlated with the average level or growth rate of neighborin firms' exports to the same market. The positive correlation is increasing in the number of of neighboring exporters in that market.

We can connect the current discussion on costs of dicovering a new market to another literature that emphasizes costly information in international trade in general, regardless of whether a market is new to the exporting country or not. Rauch (1996, 1999, and 2001), Rauch and Trindade (2002), and Casella and Rauch (2003) highlight not only that information about a foreign market is costly but also that firms often successfully tap into various social networks or organize themselves in ways to overcome the informational barriers.

If there are informational barriers to trade, diplomatic services, government-sponsored trade missions, and export promotion agencies could help alleviate such barriers. Rose (2007) formally studies this possibility in an extended grav-

ity model and finds support for this, although the trade promotion effect of the activities of foreign embassies and consulates appears to be quantitatively small. Nitsch (2007) show that state visits by foreign leaders are often associated with a big boost to bilateral trade (with an increase of about 10%), but the effect is short-lived. Ferguson and Forslid (2013) develop a Melitz-type model of government trade facilitations, which could be applied to opening of embassies and state visits, and suggest that such facilitations are most useful for medium-sized firms. Lederman, Olarreaga, and Payton (2009) document that official trade promotion agencies do appear to be associated with an increase in trade. Note that in these studies, the government's role may not necessarily be about reducing informational barriers. It could include reducing financial difficulties of exporting firms or applying political pressures to re-direct trade flows away from other trading partners.

While the relevant empirical papers are numerous, none in our reading uses a structural estimation approach, and none formally assesses the probability that both inequalities discussed in the introduction hold simultaneously in the data. In this sense, our paper may fill an important void in the literature.

2.2 The Chinese trade data

The use of the Chinese data deserves some discussion as well. The rapid growth of Chinese exports over the last decades has received attention in the academic, business, and policy worlds. The cumulative export growth of China over 2000-2006 is often comparable to two decades of export growth by the United States, Japan or Germany (the other top exporters in absolute values), and comparable to the cumulative growth over 15 years for the rest of world (from 1992 to 2006). This means that we are able to observe a large amount of actions and churning in firm-level export activities in the Chinese data.

We work to minimize possible biases introduced by the use of the Chinese data. The first concern is that an undervalued Chinese currency could artificially boost export pioneering activities, resulting in a lower estimated probability of market failure. While there are suggestions of an undervalued Chinese yuan in recent years, data suggest that the exchange rate was not under-valued during 2000-2002, the period in which export pioneering activities take place in our sample. If anything, the forward market suggests that the Chinese exchange rate may be over-valued during that period, which would bias against finding a low probability of market failure. The second concern is that export subsidies by

the Chinese government may also boost export pioneering activities, resulting in a lower observed frequency of market failure. We minimize such concerns by working with a set of sectors against which no single countervailing duty case (i.e., illegal export subsidies) has ever been lodged by any WTO member countries (even though there is no shortage of countervailing cases against other Chinese export sectors).

Mary Amity and Caroline Freund (2010) point out that during 1992 to 2005, China’s real export value grew by more than 500 percent, but by their measure of intensive margin, the export growth of existing products is the main contributor. However, taking an existing product to a new destination can also be viewed as a dimension of extensive margin growth which they do not consider. Using a broader definition of extensive margin (increases in the new product-destination pairs), Figure 1 plots the number of export markets in Chinese manufacturing from 2000 to 2006 for product definitions at different levels of disaggregation. It is not surprising that the growth rate increases with the level of disaggregation. From 2000 to 2006, the number of HS 6-digit product and country pairs grew by 66%. (Of course, the number of product and destination pairs that are yet to be explored is still large by the end of the sample period.)

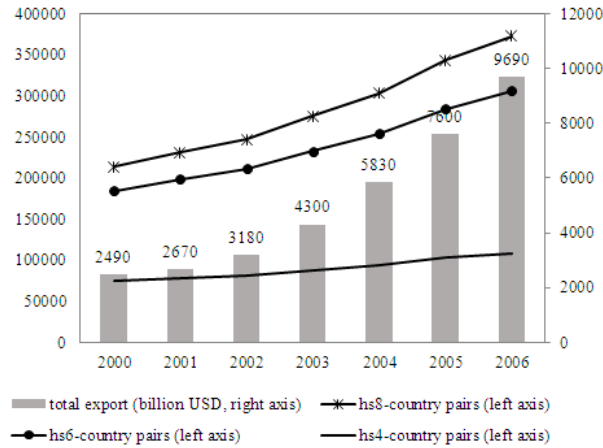


Figure 1: Export value and number of export markets in China, 2000 to 2006

We can in principle separate our methodology from our application to the Chinese data. That is, our approach can be applied to the micro customs-level trade data from other countries. Indeed, such replications can be very useful to investigate whether the probability of market failure varies by exporting

countries, and if so, why.

3 Theoretical Model

In this section, we develop a dynamic structural model for a firm’s decision on whether it wants to be a pioneer, a follower, or a non-exporter. A firm is assumed to produce a single product, and has to make an entry, stay, or exit decision in every period. (To anticipate our empirical estimation, we call each HS 6-digit line a product, and each HS 4-digit line a sector. Since the potential number of exporters for any given 6-digit product is large, typically over 300, we do not model strategic interactions. Bolton and Harris (1999) show that, when strategic considerations are present, firms would often bring forward the time of their experimentation and therefore also the information available to other firms. This suggests that in cases when the number of firms is small and strategic considerations are important, the likelihood of market failure is likely to be lower.)

3.1 Demand

We begin with the demand curve for an individual firm. Denote i as an individual firm (or firm-product variety) and fix that product k . Then for each product, the utility that a consumer c consuming firm i ’s variety in destination d time t is

$$u_{ci}^d(t) = \delta_i^d(t) + e_{ci}^d(t) \tag{1}$$

$\delta_i^d(t)$ is a firm-specific component that varies by destination and time and $e_{ci}^d(t)$ captures the heterogeneity in preferences across all consumers consuming i in destination d and time t .

Following the convention in the literature (Berry, 1994; Roberts et al., 2012), we assume that $e_{ci}^d(t)$ is an i.i.d. random variable that follows a Type I extreme value distribution. This implies that a given consumer would only consume a single variety for any given product. Then the market share of firm i in market d evolves with the following equation:

$$s_i^d(t) = \frac{\exp \delta_i^d(t)}{\sum_{j=0}^{K^d(t)} \exp(\delta_j^d(t))} \tag{2}$$

where $K^d(t)$ is the number of firm in market d at time t . (See Roberts et al.,

2012, for an identical setup.)

We will specify the consumer demand in such a way to capture both the possibility of a first mover advantage (FMA) and the possibility of consumer loyalty. FMA refers to the possibility that the demand for the first exporter's variety is higher than that for others, but this advantage could be eroded over time. Consumer loyalty is to be captured by a term that allows the demand for a firm's variety to be higher if the firm already sells the variety in this market in the previous period than if it does not. Only an export pioneer can enjoy FMA, whereas any firm can cultivate consumer loyalty. More precisely, we model the firm-specific term $\delta_i^d(t)$ as:

$$\delta_i^d(t) = \xi_i^d - \alpha_k^d \ln p_i^d(t) + \rho_k I_i^d(t-1) + I_i^d(0) (\theta_k^d - \lambda_k(t)) + u_i^d(t) \quad (3)$$

The first term, ξ_i^d , is a firm-specific demand component. The second term, $p_i^d(t)$, is the price paid by consumers in destination d for variety i in period t . The third term, $I_i^d(t-1)$, is a discrete indicator which is equal to one if the firm exported to this market in the previous period. A positive value of ρ_k would indicate the presence of consumer loyalty, although we will not restrict the value or the sign of this parameter in our estimation. The fourth term, $I_i^d(0) (\theta_k^d - \lambda_k(t))$, is meant to capture the notion of a First Mover Advantage (FMA) for an export pioneer. $I_i^d(0)$ is equal to one for an export pioneer firm and zero for all firms that follow the pioneer. The initial strength of the FMA is represented by a market-product specific θ_k^d , and it decays over time at a rate of $\lambda_k(t)$ per period. Because we do not restrict the values or the signs of these parameters in the estimation, the specification allows for the possibilities of FMA and consumer loyalty but do not impose them. We will let the data tell us their presence and strength. Note that neither customer loyalty nor FMA appear in the theoretical models by Hoff (1997) and Hausmann and Rodrik (2003). One might conjecture that the presence of these terms makes market failure less likely since a firm would have more reasons to want to be the first exporter in a market.

The last term, $u_i^d(t)$, is a random noise, whose distribution will be specified later. We could add additional market specific terms such as the destination country's log GDP and log income per capita, or market-product specific terms such as the destination country's worldwide import value of the product in question. Our estimation procedure will have time-varying destination dummies

and time-varying product dummies to absorb these terms.

We pick a product for normalization purpose and set $\delta_0^d(t) = 0$ ¹. The normalized market share for variety i in destination d , in logarithm, takes a simple form:

$$\ln \frac{s_i^d(t)}{s_0^d(t)} = \xi_i^d - \alpha_k^d \ln p_i^d(t) + \rho_k I_i^d(t-1) + I_i^d(0) (\theta_k^d - \lambda_k(t)) + u_i^d(t) \quad (4)$$

Equation (4) will be identified using data on market shares by firms in different destinations. The independent variables include price (unit export value), $p_i^d(t)$, the export status of previous period, $I_i^d(t-1)$, initial FMA, $I_i^d(0) \theta_k^d$, decay rate $-I_i^d(0) \lambda_k(t)$, and a firm-specific demand shock term ξ_i^d . However, since we simultaneously estimate the equation for multiple products (21 in the sample), and the estimation is highly non-linear, we need to impose some further structures on the parameters to make the computational burden manageable. We make the following assumptions: (1) $\alpha_k^d = \alpha^d, \theta_k^d = \theta^d$. This says that price elasticity parameter α and FMA parameter θ vary by destination but not by industry. (2) $\rho_k = \rho$; This says that if there is consumer loyalty, it does not vary by destination or sector. (3) $\lambda_k(t) = \lambda t$. This assumes that the FMA decays at a linear rate that does not depend on destination or industry. Finally we simplify equation (4) to

$$\ln \frac{s_i^d(t)}{s_0^d(t)} = \xi_i^d - \alpha^d \ln p_i^d(t) + \rho I_i^d(t-1) + I_i^d(0) (\theta^d - \lambda t) + u_i^d(t)$$

3.2 Variable Cost

We model the log marginal cost of firm i exporting to market d in period t as:

$$\ln c_i^d(t) = \gamma_k^d(t) + \gamma_{wk} \vec{w}_i(t) + \omega_i + v_i^d(t) \quad (5)$$

$\gamma_k^d(t)$ is a component that is common to all firms but varies by industry, destination, and time. It may include transportation costs, tariffs and non-tariff barriers. $\vec{w}_i(t)$ represents a set of observable components that affect a firm's marginal cost; a leading example would be wage. ω_i is firm productivity that is observed by the firm but unobserved by researchers; we assume it is time

¹When we estimate the model, we choose the average market share of all products as the normalized product.

invariant. $v_i^d(t)$ is a noise term. We assume that $u_i^d(t), v_i^d(t)$ follows an i.i.d. joint normal distribution with mean 0 and variance-covariance matrix Σ .

Assuming all firms operate in a monopolistically competitive industry, a profit-maximizing firm facing the demand in equation (3) will charge a price of

$$\ln p_i^d(t) = \ln \left(\frac{\alpha^d}{\alpha^d - 1} \right) + \gamma_k^d(t) + \gamma_{wk} \bar{w}_i(t) + \omega_i + v_i^d(t) \quad (6)$$

where $\frac{\alpha^d}{\alpha^d - 1}$ is a constant markup.

We will use unit export values as a proxy for prices charged by each firm. The pricing equation contains a destination-period effect $\gamma_k^d(t)$, a firm-specific cost term $\bar{w}_i(t)$, and an unobserved productivity shock term ω_i . The markup term depends on price elasticity α^d which varies by market. The noise term, $v_i^d(t)$, can capture, among other things, measurement errors in the price term. Again, to make the computational burden manageable, we impose some additional structures on the parameters. First, γ_{wk} is assumed to be the same across all sectors. Second, we assume $\gamma_k^d(t) = \gamma^d + \gamma_k + \gamma(t)$. That is, it is a linear sum of a destination-specific effect, an industry-specific effect, and a time-specific effect.

3.3 Firm Problem

3.3.1 Static Profit Function

Denote the destination aggregate demand as $M_k^d(t)$ and the firm's individual demand is $s_i^d(t) M_k^d(t)$. Then the log expected profit is²

$$\begin{aligned} \ln \pi_i^d(t) &= \ln E_{u,v} [s_i^d(t) M_k^d(t) (p_i^d(t) - c_i^d(t))] \\ &= \ln E_{u,v} \left[\frac{\exp(\delta_i^d(t))}{\sum_j \exp(\delta_j^d(t))} M_k^d(t) \frac{1}{\alpha^d} p_i^d(t) \right] \end{aligned}$$

Define $Y_k^d(t) = \frac{M_k^d(t)}{\sum_j \exp(\delta_j^d(t))}$. Combining it with the pricing equation and demand equation before, we obtain the firm's log profit as

$$\ln \pi_i^d(t) = \ln \left(\frac{1}{\alpha^d} \right) + \xi_i^d + \rho I_i^d(t-1) + I_i^d(0) (\theta^d - \lambda t) + (1 - \alpha^d) E_{u,v} \ln p_i^d(t) + \ln Y_k^d(t) \quad (7)$$

²The expectation is taken over two random noise terms $u_i^d(t)$ and $v_i^d(t)$.

where

Substituting all equations into equation (7), and denoting $\mu^d = \frac{\alpha^d}{\alpha^d - 1}$, here we have

$$\ln \pi_i^d(t) = \ln \left(\frac{1}{\alpha^d} \right) + \ln \bar{Y}_k^d(t) + \ln \bar{r}_i^d(t) + \ln b_i^d(t) \quad (8)$$

where

$$\ln \bar{Y}_k^d(t) = \ln Y_k^d(t) + (1 - \alpha^d) (\ln \mu^d + \gamma^d + \gamma_k + \gamma(t)) + C_{uv}$$

$$\begin{aligned} C_{uv} &= \ln E_{u,v} [\exp (u_i^d(t) + (1 - \alpha^d) v_i^d(t))] \\ \ln \bar{r}_i^d(t) &= \xi_i^d + (1 - \alpha^d) (\gamma_{wk} \bar{w}_i(t) + \omega_i) \\ \ln b_i^d(t) &= \rho I_i^d(t - 1) + I_i^d(0) (\theta^d - \lambda t) \end{aligned} \quad (9)$$

In equation (8), the first term is markup in percentage term. The second term, $\ln \bar{Y}_k^d(t)$, captures all factors that are common to all firms in a particular sector, destination, and time period. It includes both the aggregate demand and common marginal cost terms. The third term, $\ln \bar{r}_i^d(t)$, is a composite term that captures a firm-specific demand shifter ξ_i^d , an unobserved cost shifter ω_i , and observed firm characteristics $w_i(t)$. The last term, $\ln b_i^d(t)$, captures customer loyalty and the first mover advantage.

3.3.2 To Be an Exporter or Not ?

Let us first consider the decision problem facing a firm in a market already explored by a pioneer. We represent the time periods in such cases by period $t > 0$. A firm is assumed to need to consider whether to export or not in each period. (For a firm that exports in the previous period, deciding to not export this period is equivalent to deciding to exit.) At the beginning of each period, a firm draws a fixed cost of exporting its variety to market d , denoted by $\phi_i^d(t)$, from a distribution. All information other than those in $b_i^d(t)$ and $\phi_i^d(t)$ is perfect foresight. Let $\Omega_i^d(t) = \{\xi_i, \omega_i, w_i(t), \bar{Y}_k^d(t), b_i^d(t), \phi_i^d(t)\}$. For simplicity, we assume $\ln Y_k^d(t)$ can be written as summation of destination, sector and time dummies. Furthermore, we assume $w_i(t), \bar{Y}_k^d(t)$ are exogenous first-order Markov process. Then we define the value of the firm at time t as

$$V(\Omega_i^d(t)) = \max_{I_i^d(t) \in \{0,1\}} \left\{ \left[\pi_i^d(t) - \phi_i^d(t) \right] I_i^d(t) + \beta E_\phi V(\Omega_i^d(t+1)) \right\} \quad (10)$$

$$s.t. \quad (9)$$

In equation (10), we have two terms. The first part says that by choosing to export today, $I_i^d(t) = 1$, the firm can obtain a current profit of $\pi_i^d(t) - \phi_i^d(t)$. The second term is the discounted future value where the discount factor is $\beta \in (0, 1)$. When the firm chooses $I_i^d(t) = 1$, then future state variable $b_i^d(t+1)$ will change: it can increase next period's expected profit. The solution to the problem is a cutoff rule: if $\phi_i^d(t)$ is smaller than a cutoff value $\bar{\phi}_i^d(t)$, then the firm will export.

3.3.3 To Be a Pioneer or Not ?

Let us consider a firm's optimization problem in a market not yet explored by a pioneer (we denote the time period as $t = 0$). We assume that all firms have the same cost of discovering a new market d , denoted by F_k^d , which needs to be paid on top of the export fixed cost discussed in the previous discussion. We use χ to denote the probability that at least 1 firm will become a pioneer firm. Notice that χ depends on the distribution of the economy. Hence the firm's problem state variables should include the distribution of individual state variables $f(\Omega_i^d(0))$ and can be written as

$$\bar{V}(\Omega_i^d(0), f(0)) = \max_{I_i^d(0)} \left\{ \begin{array}{l} \left[\pi_i^d(0) - \phi_i^d(0) - F_k^d \right] I_i^d(0) + \beta I_i^d(0) E_\phi V(\Omega_i^d(1)) \\ + \beta (1 - I_i^d(0)) \left[\chi E_\phi V(\Omega_i^d(1)) + (1 - \chi) E_\phi \bar{V}(\Omega_i^d(1), f(1)) \right] \end{array} \right\} \quad (11)$$

$$s.t. \quad (9)$$

In $\Omega_i^d(1)$, $b_i^d(1) = \rho + \theta^d - \lambda$. It means that firm chooses to become a pioneer firm. In $\Omega_i^d(1)$, then $b_i^d(1) = 0$. It is the case that firm i does not choose to become pioneer hence it does not enjoy the FMA. The above equation says that if the firm chooses to become a pioneer, $I_i^d(0) = 1$, it would obtain a profit of $\pi_i^d(0) - \phi_i^d(0) - F_k^d$. It will also enjoy a FMA that is captured by $b_i^d(1)$. The optimization problem yields another cutoff value $\tilde{\phi}_i^d$: If a firm draws a export cost $\phi_i^d(0) < \tilde{\phi}_i^d$, then it will choose to become a pioneer firm. Then we can define $\chi = 1$ if $\max_i (\tilde{\phi}_i^d - \phi_i^d(0)) > 0$ and 0 otherwise.

Denote the probability that a firm would become an exporter in a market already explored (i.e., in period $t > 1$) by p_e^d , and the probability of that a firm would become a pioneer exporter in period $t = 0$ by p_p^d . We assume ϕ follows a

normal distribution with parameter ψ^3 , and we use G to denote the cdf function of a standard normal distribution.

$$p_e^d(\Omega_i^d(t)) = \Pr[\phi \leq \bar{\phi}_i^d(t)] = G[\Omega_i^d(t); \psi] \quad (12)$$

$$p_p^d(\Omega_i^d(0)) = \Pr[\phi \leq \tilde{\phi}_i^d] = G[\Omega_i^d(0); \psi] \quad (13)$$

Equation (12) says that probability of exporting at time t is equivalent to firm i drawing a fixed cost lower than $\bar{\phi}_i^d(t)$. The cutoff value $\bar{\phi}_i^d(t)$ is a function of state variable $\Omega_i^d(t)$. Given parameters ψ , then p_e^d is a function as $G[\Omega_i^d(t); \psi]$. Next equation (13) is similar as equation (12). Cutoff value $\tilde{\phi}_i^d$ is a function of $\Omega_i^d(0)$. Hence $p_p^d = G[\Omega_i^d(0); \psi]$.

4 Estimation Procedure

For each firm, we observe a sequence of cost shifter $w_i(t)$ and a participation choice $I_i^d(t)$. If a firm exports, we observe its unit export value, $p_i^d(t)$, and market share $s_i^d(t)$. We denote the data set as D_f . Our empirical model consists of four structural equations: a demand equation (4), a pricing equation (6), an export decision rule (12) and a pioneer decision rule (13). Each equation contains unobserved firm productivity, ω_i , and unobserved preference shifter, ξ_i^d . Our estimation strategy utilizes the framework of average likelihood function, following Arellano and Bonhomme (2011) and Roberts et al. (2012). Intuitively, we could estimate ω_i and ξ_i^d using data on individual firm prices and quantities, conditional on a set of common parameters. Since a firm's export and pioneering decisions place restrictions on ω_i and ξ_i^d , we let the contributions by these unobserved variables to the likelihood function be weighted by a specified distribution.

The parameters in the demand, pricing, and export equations are denoted by $\Theta = \{\alpha^d, \rho, \lambda, \theta^d, \gamma^d, \gamma_k, \gamma(t), \gamma_{kw}, \Sigma, \psi, F_k, F^d\}$ ⁴. We denote the joint distribution of firm i 's unobserved shocks ξ_i, ω_i as a weighting function $f(\xi, \omega)$. Then an average likelihood function is defined as

$$l(D_f|\Theta) = \int l(D_f|\Theta, \xi, \omega) f(\xi, \omega) d\omega d\xi$$

³ ψ includes export fixed cost mean and standard deviation.

⁴There are $7+1+1+7+7+3+4+5+3+1=39$ parameters.

where $l(D_f|\Theta, \xi, \omega)$ is the likelihood function if ξ, ω are to be observed.

$$l(D_f|\Theta, \xi, \omega) = \prod_{d,t} g[\ln(s_i^d(t)/s_0^d(t)), \ln p_i^d(t); \Sigma]^{I_i^d(t)} G[\bar{\phi}_i^d(t); \Theta]^{I_i^d(t)} [1 - G(\bar{\phi}_i^d(t); \Theta)]^{1-I_i^d(t)} \\ G(\tilde{\phi}_i^d; \Theta)^{I_i^d(0)} [1 - G(\tilde{\phi}_i^d; \Theta)]^{1-I_i^d(0)}$$

where G is the cdf of a normal distribution (with g denoting its probability density function).

Similar to Roberts et al. (2012), our likelihood function has two parts⁵. The first part is the contribution of the firms' market shares and price data, and the second part is the contribution from the firms' choice on exports. Following Roberts et al. (2012), we use a Gibbs sampler to simplify computation. In particular, we first estimate the demand and pricing equations to obtain common demand and cost parameters, and then use a flexible polynomial function to approximate the latent payoff if firm i exports to market d at time t .

$$V_i^{de}(t) - \phi_i^d(t) - V_i^{dn}(t) = H[\xi_i^d, \alpha^d \omega_i, \bar{w}_i(t), I_i^d(0) (\theta^d - \lambda t), I_i^d(0) = 1, \bar{Y}_k^d(t); \psi] \quad (14)$$

$$\tilde{V}_i^{de}(t) - \phi_i^d(t) - \tilde{V}_i^{dn}(t) = \tilde{H}[\xi_i^d, \alpha^d \omega_i, \bar{w}_i(t), I_i^d(t-1), I_i^d(0) = 0, \bar{Y}_k^d(t); \psi] \quad (15)$$

Here we use $V_i^{de}(t), V_i^{dn}(t)$ to denote pioneer firm value if exports or not exports and $\tilde{V}_i^{de}(t), \tilde{V}_i^{dn}(t)$ denote follower firm value if exports or not exports. Firm will export iff latent payoff is greater than 0. H is a polynomial function which approximates the latent payoff. In our estimation, we use a linear function as H .

In the pioneer equation, we can see firm will choose to become pioneer iff

$$V_i^{de}(0) - \phi_i^d(0) - \tilde{V}_i^{dn}(0) - F_k^d > 0 \quad (16)$$

$V_i^{de}(0)$ means that at initial period, firm chooses to export (become pioneer firm). $\tilde{V}_i^{dn}(0)$ says that firm chooses not to export at pioneer period then the

⁵In the appendix, we explain our estimation techniques in detail.

value of the firm is

$$\tilde{V}_i^{dn}(0) = \beta [\chi E_\phi V(\Omega_i^d(1)) + (1 - \chi) E_\phi \bar{V}(\Omega_i^d(1))]$$

. The difference between equation (16) and (14) is: in (14), firm can not choose his pioneer status; while in (16) firm needs to pay a discovery cost F_k^d . We approximate the above equation with a linear function again.

$$V_i^{de}(0) - \phi_i^d(0) - \tilde{V}_i^{dn}(0) - F_k^d = H_x \left[\xi_i^d, \omega_i, \vec{w}_i(0), \bar{Y}_k^d(0); \psi \right] \quad (17)$$

We explain the estimation details in the appendix.

4.1 Identify F_k^d

To identify F_k^d we compute in this way: (1) We evaluate estimation equation in 14 at period 0 and then take difference with pioneer latent payoff we get

$$H_x(0) - H(0) = V_i^{dn}(0) - \tilde{V}_i^{dn}(0) - F_k^d \quad (18)$$

$V_i^{dn}(0)$ is the counterfactual firm value: follower firm value assuming it can enjoy the FMA. $\tilde{V}_i^{dn}(0)$ is the real value if a firm chooses not to become an pioneer.

(2) Notice that in our sample, $\chi = 1$. Then we can estimate $V_i^{dn}(0)$, $\tilde{V}_i^{dn}(0)$ by solving value functions

$$V^d(\Omega_i) = \max(H(\Omega_i), 0) + \beta \int V^d(\Omega_i') f(\phi) d\phi$$

The firm-specific demand and cost components are sampled firm by firm and we can estimate their joint distribution. We Bayesian update the firm-specific parameters ξ, ω . Assuming ξ, ω follow a joint normal distribution with parameters W^6 , we update W in each iteration from the previous sampling step.

⁶ W includes a mean and a variance-covariance matrix.

5 Data Description

5.1 Identifying New Markets, Pioneers, and Followers

We have monthly firm-product-destination level export data from the Chinese customs covering the 84 months from January 2000 to December 2006. We have annual product-destination level export data from China from the UN Comtrade database for a much longer time period, but the Comtrade data do not have firm-level information, which is crucial for our research question. Because our system of four non-linear equations is complex, we have 90 parameters to estimate in our baseline model even after making a number of simplifying assumptions. Each round of estimation takes about 12 hours. This suggests that it is wise for us to focus on a subset of sectors in this project. (As we have noted earlier, our approach can in principle be applied to other sectors and indeed to the customs level export data from other countries. We leave these for future research.)

In this paper, we work with the Chinese exporters of 21 electronics products spanning four 4-digit sectors (HS 8525-8528) in the HS Chapter 85 (electrical machinery equipments). We call a product destination pair a market. Based on UN Comtrade data (available at the bilateral product level but no firm-level information), we first identify a set of markets for which China did not export to during 1996-1999 but did during 2000-2002⁷. We then use the Chinese customs data from 2000-2006 to identify, for each of the newly explored market, who the first exporter is, who the followers are, and how their market shares evolve. In other words, we identify all the export pioneering activities (593 in total) during 2000-2003 and trace the dynamics of both the pioneers and all followers during 2000-2006.

Our 21 products come from four consumer electronics sectors from Chapter HS85 (Electrical Machinery and Equipment). They are (1) four products from HS8525, transmission apparatus for radiotelephony, TV cameras, and cordless telephones, (2) three products from HS8526, radar apparatus, radio navigation aid, and remote control apparatus, (3) nine products from HS8527, reception apparatus for radiotelephony etc, and (4) five products from HS8528, television receivers. Key features of these four sectors are reported in the first panel of Table 1. Two of the sectors have relatively low growth rates (HS8526 and HS8527), whereas the other two have a relatively fast growth rate (HS8525 and HS8528). This will offer us a chance to see whether the inference on the

⁷We start the Comtrade data in 1996 in order to bypass a reclassification of HS codes from 1995 to 1996.

sector	HS8525	HS8526	HS8527	HS8528
average annual growth rate, 2000-2002	46.8%	6.6%	1.8%	36.6%
export share in HS85 in 2002	10.6%	0.1%	4.6%	3.6%
export share in China in 2002	1.8%	0.0%	0.8%	0.6%
export share in the world of the same sector in 2002	7.8%	1.7%	20.5%	7.6%
number of 6-digit products	4	3	9	5
number of markets (# product x 220 countries)	880	660	1980	1100
% of total # markets accounted by:				
existing markets by end of 1999	21%	11%	43%	35%
newly explored markets during 2000-2002	23%	9%	9%	14%
unexplored markets as of end of 2002	56%	80%	49%	51%
Total number of exporters (for all products) in 2002	641	255	2185	1024
mean [median] # exporters per product in 2002	160 [160]	85 [29]	243 [295]	205 [103]
mean [median] # exporters per existing market in 2002	6 [2]	5 [2]	10 [4]	8 [3]
mean [median] # destinations a firm exported to in 2002	3 [1]	2 [1]	4 [1]	4 [1]

Table 1: Sample distribution of sector 8525-8528

likelihood of market failure is strongly influenced by the growth rate of a sector.

Note that by the end of 1999, these four sectors had entered different numbers of markets. Therefore the remaining space for new market exploration during 2000 to 2002 were different ex ante. In particular, HS8526 is relatively under-explored by the end of 1999 whereas HS8527 is relatively more explored. The distribution of the matured markets as of end of 1999, newly discovered markets during 2000-2002, and still unexplored markets as of the end of 2002 are summarized in the second panel of Table 1.

We label any firm a pioneer if it exports in the very first month in which China exports a particular product to a particular destination. We call subsequent entrants as followers. While it is possible to have more than one pioneer firm for a given product-destination pair, we find that there is only a single pioneer firm in 97% of all the newly explored markets during 2000-2003. Of the remainin 3% of the cases, there are two pioneers. In no case in which we find three or more pioneer firms. While the potential number of exporters for any product is relatively large (typically over 2000), the number of entrants in any give market is low (often between 3-10).

5.2 Descriptive dynamics in the new markets

We now provide some descriptive dynamics of pioneers and followers in the markets that are first explored during 2000-2003. Let us call the month in

which export pioneering activity takes place Period 1. We define Period 2 as the first 12 months following the export pioneering activities, Period 3 as the second 12 months following the export activity, and so on. Given the constraint of our data, we focus on the first 5 periods.

Panel (a) of Table 2 summarizes the number of exporters that ever presented in each new market since its emergence till the end of 2006, as well as the number of active firms in each period. For each indicators, we report the 90th percentile, the mean and median value. In addition to the full new market sample, we also list the corresponding statistics for new markets that survived through 2006 (there are 394 such cases). The results are presented in Panel (b) of Table 2. It shows that the average number of entrants in each period is very small for both samples. Even in period 5, corresponding to the fourth year after the emergence of new markets, on average only 6-7 firms entered (the median numbers are 3 and 4, respectively).

(a) All new markets			
	90th percentile	mean	median
# of exporters ever present	32	13	5
# of active firms in each period			
period1	1	1	1
period2	3	2	1
period3	6	3	2
period4	9	4	2
period5	14	6	3
(b) New markets survived through 2006			
	90th percentile	mean	median
# of exporters ever present	42	18	10
# of exporters ever present			
period1	1	1	1
period2	3	2	1
period3	6	3	2
period4	10	4	3
period5	14	7	4

Table 2: Average number of entrants

Note: In sector of HS8525-8528, the 90th percentile, mean and median of firm numbers in each mature markets in 2000 are 23, 9 and 3.

It is useful to compare the characteristics of pioneers versus followers to reveal the role of firm heterogeneity. (Recall that some consider pioneering

activities occur for purely random reason; See Wagner (2012)). Others find that the likelihood of being a pioneer exporter is strongly correlated with firm level productivity. That is, a more productive firm is more likely to be an export pioneer (see Freund and Pierola, 2012). Table 3 lists some cost and export characteristics of pioneers and followers. Due to data limitations, we only consider three cost variables⁸: (1) whether the firm is a processing exporter, (2) its type of ownership, and (3) city-level local wage (using data at the year of 2000) where the firm is located. Panel A of Table 3 reports that 40% of the pioneer firms engaged in processing trade, compared with 39% for the followers. Mean comparison test shows the difference between pioneer and follower is not statistically significant. The ownership type seems to matter a lot for firm’s sequence of entry. 57% of pioneers are state-owned enterprises (SOE), 11% are foreign-invested firms (FIE), and 17% are joint ventures (JV). As a comparison, 26% of followers are SOEs, 25% are FIEs, and 25% are JVs. Besides, the local wage for pioneers is lower than that for followers, indicating that pioneer firms on average have cost advantages. The pioneer vs. follower differences for both ownership and local wage are significant at 1% level. However, these statistics need to be re-considered given the fact that before 2002, only a small proportion of non-SOEs in China were permitted to export abroad. Most of the private firms, JV and FIE had to export through intermediary trading firms, most of which were SOEs. This indicates the role of SOE might be over-evaluated. Therefore, Panel B reports the statistical result based on a sub-sample of firms, the non-intermediaries. It is found that the patterns are similar to the full sample, only with less distinction on the share of SOEs between pioneers and followers. The difference regarding processing share is more significant than before. Panel C further compares the initial export value and export experiences of pioneers and followers. We focus on new markets emerged in 2001 and 2002 in Panel C (385 markets), so that we could study the firms’ initial characteristics in 2000, before any firm made entry decisions into the new markets yet. Data show that pioneers have better performances in terms of being a larger exporter,

⁸The data used in our estimation are all obtained from the General Administration of Customs of China, which shed little light on firm’s cost variables, such as wage and capital. Although some researchers have employed a matched dataset between the customs data and China’s annual survey of manufacturing firms to gain more detailed cost information, this won’t work for our study. Our estimation requires the full sample of pioneers and corresponding non-pioneers to identify the discovery cost and FMA. However, in our selected sector only 44% of the firms (3356 out of 7694 firm-market pairs) could be matched, and around 64% of the pioneer firms are out of this sample. As a substitute, we use the city-level local wage to reflect firm’s labor cost, where local wage are calculated using firm-level data in the manufacturing survey data.

Variable	Pioneer	Follower	Mean comparison
A. Full sample			
Processing firm	40%	39%	Insignificant
SOE	57%	26%	Significant at 1%
FIE	11%	25%	Significant at 1%
JV	17%	12%	Significant at 1%
Local wage	1.05	1.15	Significant at 1%
B. Non-intermediary firm			
Processing firm	61%	56%	Significant at 5%
SOE	35%	18%	Significant at 1%
FIE	20%	38%	Significant at 1%
JV	31%	18%	Significant at 1%
Local wage	1.09	1.15	Significant at 1%
C. Entrant for new market emerged in 2001 and 2002			
Mean export value in 2000 (million)	500	124	Significant at 1%
Exported of this product in 2000	43%	9%	Significant at 1%
Exported to this country in 2000	35%	14%	Significant at 1%

Table 3: Comparison between Pioneers vs. Followers

with more relevant export experience to the new market (both on the product side and destination side). Specifically, the average export value of pioneers was 500 million in 2000, compared with 124 million for followers. In addition, 43% of pioneers had exported the same product to other countries and 35% exported other products to the same country, which are both significantly higher than followers.

We then make a comprehensive description of the pioneer firm's export status in the new markets. Two dimensions are considered in each period: (1) the pioneer firm's leading position, and (2) market concentration. To measure the first dimension, we classify the pioneer's export value into three groups: (i) pioneer firm was one of the largest two Chinese exporters in the new market, (ii) pioneer firm exported to the new market but was neither of the largest two, and (iii) pioneer firm didn't export. To measure the second dimension, market concentration, we adopt the largest two exporters' market share and cluster them into five groups: (i) (75%, 100%], (ii) (50%, 75%], (iii) (25%, 50%], (iv) (0%, 25%], and (v) no export. Here market share is calculated by firm's export quantity over total export quantity of all Chinese exporters in that market and period. A pioneer is considered to be the most successful if it is in the leading

position of a concentrated market. The reason we use the largest two exporters' market share to measure market concentration, instead of the top 4's as in typical IO literature, is due to the actual number of exporters in each given period is normally small (see Table 2).

In Figure 2 , we present the evolution of the pioneer firm's leading position and market concentration over time. The above two dimensions group our sample into 13 grids, and the distribution of each grid is represented by a solid bubble, with bubble size measuring the percentage that has the corresponding characteristics. In period 1, there is supposed to be only one 100% size bubble in the upper-right corner, due to that the full market share belongs to the pioneer firm by definition. In period 2 , we draw a hollow circle in upper-right corner as the footprint of period 1, while the solid bubbles describe the pioneer status in period 2. The largest one, whose size is 48%, is the case that no firm exported to the market in period 2. The second largest, 25%, corresponds to the situation that the pioneer didn't export while follower firms took over the leading position (accounting for more than 75% of the total market sales). It is to be noticed that only 24% of the samples' pioneer firms were still the largest and got hold of more than 75% of the market share, which is the initial and most preferable situation for the pioneer firm. The other bubbles are relatively smaller.

In period 3 to 5 , we could observe the trend of how each bubble evolve across time. More and more pioneer firms chose not to export, and the new markets became more and more dispersed. In period 5, only 6% of the pioneer firms were still exporting, with 4 percentage points were really successful by being one of the largest exporters in a concentrated market. 48% of the full sample are cases where pioneer firms didn't export and new markets were occupied by only followers with different levels of concentration. The rest 40% have no entrants in period 5.

6 Empirical Results

In this section, we apply the structure model spelled out above to data on Chinese exports in 21 HS 6-digit products with four 4-digit HS sectors from 8525 to 8528. Our model estimates price elasticity and FMA by destinations, and the estimate discovery cost using both product and destination components. The more products and countries we include, the more parameters we are going to estimate. To further reduce computational time, we assume all 6-digit products

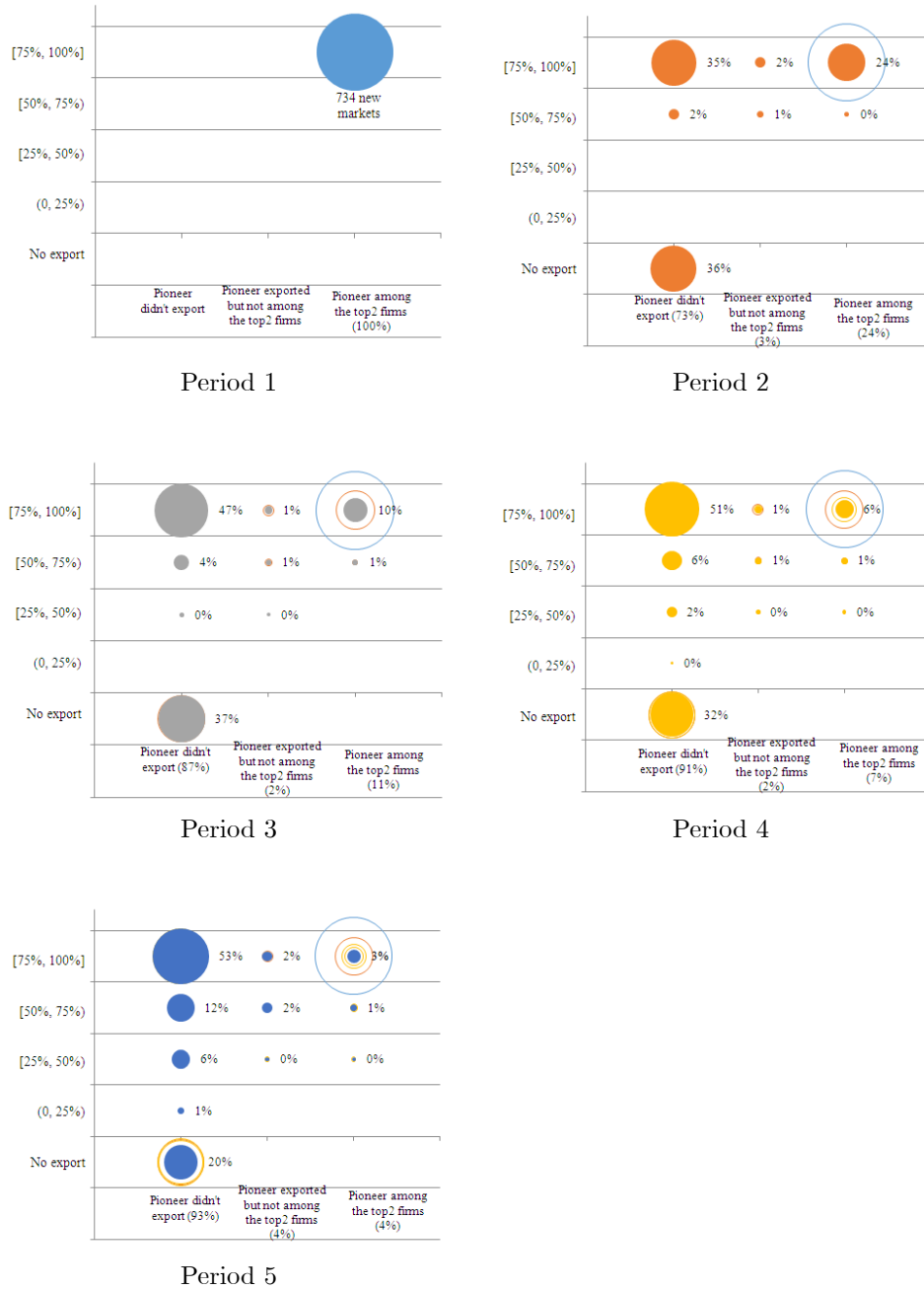


Figure 2: Evolution of pioneer leading position

Destinations (# of countries)	existing markets	new markets	unexplored markets
US, Canada (2)	90%	5%	5%
Other western hemisphere (52)	18%	9%	73%
Former Soviet Republics (15)	24%	16%	60%
Other European countries (42)	34%	13%	53%
JPN/KOR/AUS/NZL (4)	81%	14%	5%
Rest of Asia (42)	46%	15%	39%
Africa (60)	24%	13%	63%

Table 4: Distribution of existing, new and unexplored markets by regions

within a given 4-digit sector share the same parameter. We cluster all countries into 7 destination regions according to their geographical and socioeconomic features: (i) US/Canada, (ii) Other western hemisphere, (iii) Former Soviet Republics, (iv) Rest of Europe, (v) Japan, Korea, Australia, New Zealand, (vi) Rest of Asia, and (vii) Africa. We also assume all countries within the same region share the same coefficients. For similar computational considerations, Roberts et al. (2012) had to make similar simplifying assumptions. Even with these simplifications, we still have 90 parameters to estimate. Each round of estimation takes about 12 hours to complete.

Table 4 presents the distribution of new markets across these regions. It shows that rich regions such as US/Canada, JPN/KOR/AUS/NZL are well-explored regions for China, while developing or far-away regions like Other western hemisphere, Former Soviet Republics and Africa are significantly less explored.

We define time periods following the definitions in section 2. We then summarize firms' average participation rate into each market across time and destinations. The participation rate is calculated as A over B, where A is the number of actual entrants in a given market and period, and B is the total number of firms that produced the same 6-digit product and entered at least one new destination during the sample period. The results are presented in Table 5.

6.1 Demand and FMA Estimates

Table 6 reports estimates of the demand curve parameters, as equation (4) shows. It includes the destination-specific price elasticity α , destination-specific

Destinations	period1	period2	period3	period4	period5
US, Canada	0.1%	0.3%	0.6%	0.7%	2.2%
Other western hemisphere	4.5%	4.3%	5.6%	8.6%	13.4%
Former Soviet Republics	2.2%	2.0%	2.4%	4.3%	5.2%
Rest of Europe	4.3%	5.0%	8.8%	14.2%	24.3%
JPN/KOR/AUS/NZL	0.7%	0.8%	2.0%	2.8%	4.6%
Rest of Asia	5.6%	5.1%	6.9%	11.1%	18.3%
Africa	6.8%	3.7%	3.8%	5.1%	7.5%

Table 5: Average participation rates by region and period

initial First Mover Advantage (FMA) $I_i^d(0)\theta_k^d$, linear decay rate $I_i^d(0)(-\lambda t)$ and a dummy variable for prior sales in the market $\rho I_i^d(t-1)$. The first panel of Table 6 reports price elasticity α . For example, the price elasticity of US/Canada is -2.69, indicating that 1% increase in price will lead to 2.69% decrease of market share, and the result is statistically significant. The second panel reports the initial FMA parameters for each region and their universal decay rate. The initial FMA parameters are positive and statistically significant. FMA of US/Canada is the lowest among all 7 destination regions. Its value of 3.78 implies exporting first will increase period 1's market share by 3.78%. with a linear per-period decay rate λ estimated at -0.17, the first mover advantage disappears after 6 or 7 periods. The last panel is benefits from prior exporting behavior, which will increase market share by 0.32%.

6.2 Pricing Equation Estimates

Table 7 reports parameter estimates of the pricing equation (equation 6). To control for $w_i(t)$, we include firm's ownership type (majority state owned, wholly foreign owned, foreign-Chinese jointly owned, and the others), status of processing trade, and average wage in the city where a firm is located (the average is computed excluding the firm's own wage). A full set of destination dummies, industry dummies and period dummies are also included. Our model suggests that SOEs, JVs and FIEs have marginal costs that are 0.01%, 0.27% and 0.11% lower than the other firms, respectively. Firms involved in processing trade have a lower marginal cost, and firms located in higher-wage cities have a higher marginal cost.

parameter	mean	std.	significance
Price elasticity-US/Canada	-2.6045	0.1109	*
Price elasticity-Other western hemisphere	-2.5241	0.0487	*
Price elasticity-Former Soviet Republics	-2.4677	0.0547	*
Price elasticity-Rest of Europe	-2.4888	0.0439	*
Price elasticity-JPN/KOR/AUS/NZL	-2.3244	0.0773	*
Price elasticity-Rest of Asia	-2.4436	0.0384	*
Price elasticity-Africa	-2.4257	0.0431	*
FMA-US/Canada	3.6244	1.3423	*
FMA-Other western hemisphere	0.796	0.2925	*
FMA-Former Soviet Republics	0.6329	0.3594	*
FMA-Rest of Europe	2.0401	0.2905	*
FMA-JPN/KOR/AUS/NZL	1.9707	0.5319	*
FMA-Rest of Asia	1.6951	0.2768	*
FMA-Africa	0.6463	0.2887	*
Linear decay rate	-0.1485	0.0656	*
Export history	0.3034	0.0891	*

Table 6: Demand and FMA estimates

parameter	mean	std	significance
SOE cost add-up	-0.0177	0.0626	
JV cost add-up	-0.2477	0.0969	*
FIE cost add-up	-0.1668	0.091	*
Local wage	0.046	0.0996	
Processing status	-0.9786	0.0624	*
Destination, period, sector dummies included			

Table 7: Pricing Equation Estimates

Parameters	mean	std	significance
Export history	0.9037	0.0416	*
SOE	-0.0747	0.0288	*
JV	-0.2727	0.0434	*
FIE	-0.5692	0.0514	*
Local wage	-0.1112	0.0791	
Processing status	9.0527	0.3538	*
Productivity shock	0.109	0.0098	*
Pioneer FMA	0.0873	0.0078	*
Preference shock	0.0265	0.0534	
Sector and destination*period dummies included			
FMA effects controlled			

Table 8: Export Participation Equation

6.3 Export Participation Estimates

The third equation we estimate is the exporting decision after period 1, equation (12). The export decision depends on lagged export status, ownership dummies, processing status and local wages. The unobserved firm demand and cost components ξ_i and ω_i , pioneer firm's FMA residual, and destination*period dummies may also affect a firm's export decision and are also included. The regression results are reported in Table 8. The coefficients capture the effect on static profit of each independent variable. We see that if a firm exported last period, its current profit increases by 0.91. The profit of SOEs is overall lower than that of Non-SOEs' by 0.08. Firms located in richer cities have a higher profit than those in poorer cities. In addition, processing firms' profit is significantly higher than non-processing firms.

6.4 Pioneering Decision Estimates

The last equation we estimate is the decision on being an export pioneer equation (equation 13). Table 9 reports the estimation results. This equation includes destination dummies and sector dummies (to capture destination and sector specific discovery costs), ownership dummies, local wage and processing status. Unobserved firm demand and cost components ξ_i, ω_i are also included. The first part in Table 9 reports the destination specific components of the discovery cost. We set US/Canada as benchmark destination so the coefficients on all

parameter	mean	std	significance
Discovery cost: US/Canada	Benchmark		
Discovery cost: Other western hemisphere	1.272	0.1799	*
Discovery cost: Former Soviet Republics	0.972	0.1899	*
Discovery cost: Rest of Europe	1.129	0.1725	*
Discovery cost: JPN/KOR/AUS/NZL	0.4497	0.236	*
Discovery cost: Rest of Asia	1.4439	0.1678	*
Discovery cost: Africa	1.6414	0.1784	*
Discovery cost: 8525	-3.4657	0.1719	*
Discovery cost: 8526	-3.3348	0.1794	*
Discovery cost: 8527	-2.9053	0.1724	*
Discovery cost: 8528	-3.4307	0.1756	*
SOE	0.2985	0.0624	*
JV	-0.3703	0.1202	*
FIE	-0.7465	0.1252	*
Local wage	-0.3411	0.1011	*
Processing status	8.2082	1.1671	*
Productivity shock	0.0355	0.0242	
Preference shock	-0.0126	0.0183	

Table 9: Pioneering Equation Estimates

other regions are relative to the benchmark. The second part in Table 9 correspondingly reports sector-specific components of the discovery cost. In addition, SOEs, firms located in lower-wage cities, and processing firms are more likely to become pioneers.

7 Market Failure in Decentralized Economy

As we stated at the beginning of the paper, market failure occurs if and only if two inequalities are satisfied simultaneously. First, the discovery cost for entering a new market has to be strictly smaller than the sum of the expected profits of all potential exporters in that market. Otherwise, even a social planner would not want to pay the discovery cost to discover that new market. Second, the discovery cost has to be greater than the expected profit of any individual firm. Otherwise, some firm will find it profitable to unilaterally pay the discovery cost in spite of its inability to capture all the value of the discovery, and the knowledge spillover will take place anyway.

In this section, we formally consider a social planner's optimization problem. The planner could require all entrants to share the discovery cost (regardless of the sequence of entry). A market is now worth entering as long as the social value (or the sum of the value of all entrants) is higher than the discovery cost. Without loss of generality, let us assume the social planner always asks the most profitable firm to be the pioneer. We show that this determines a lower cut-off point of productivity for export pioneering to take place than in a decentralized economy.

7.1 Social Planner Problem

The planner maximizes the total value of all firms in this economy by choosing whether to ask a firm to enter the market $\tilde{I}_i^d(t) \in \{0, 1\}$.

$$\max_{\tilde{I}_i^d(t) \in \{0,1\}} E_0 \sum_i \left\{ \sum_{t=0}^{\infty} \beta^t [\pi_i^d(t) - \phi_i^d(t)] \tilde{I}_i^d(t) \right\} - \tilde{I}_i^d(0) F_k^d \quad (19)$$

s.t. (7)

The above planner problem is defined for a given industry and a given destination. The term in the big braces is the discounted export profit for one firm i . It has two parts. $\pi_i^d(t)$ follows the same as decentralized market. If planner chooses i to export at time t ($\tilde{I}_i^d(t) = 1$), then the firm needs to pay a fixed export cost $\phi_i^d(t)$. The last term captures that if firm i is chosen to be the pioneer exporter, then it must also pay the discovery cost F_k^d .

After period 1, the planner has exactly the same decision rule as the decentralized market. Hence we can rewrite the planner's problem as:

$$J(f(0)) = \max_{\tilde{I}_i^d(0)} \sum_i \left\{ [\pi_i^d(0) - \phi_i^d(0) - F_k^d] \tilde{I}_i^d(0) + \beta \left(\sum_i \tilde{I}_i^d(0) \right) E_\phi [V(\Omega_i^d(1))] \right\} + \beta \left(1 - \sum_i \tilde{I}_i^d(0) \right) J(f) \quad (20)$$

s.t. (11).

The first part of this problem is the case in which planner chooses at least one firm to enter. The second part is the firm value in which planner chooses no firm to enter. Define $x_i = \beta V^F(0) + \max(\pi_i^d(0) - \phi_i^d + \beta E_\phi V^P(1) - \beta V^F(1), 0)$ which is the payoff if planner chooses firm i to be the pioneer. And $x = \sum x_i$, then problem (20) can be simplified as

$$J(x) = \max \{x - F_k^d, \beta E_{x'} J(x')\} \quad (21)$$

Compare the choice of the pioneer in problem (20) and (11). Given same initial distribution $f(0)$, then in a decentralized economy, firm will choose to become pioneer iff

$$x_i > F_k^d \quad (22)$$

In the planner problem, at least one firm will become a pioneer iff

$$x > \beta E_{x'} J(x') \quad (23)$$

This equation says that the total gain of choosing one firm to become a pioneer is greater than F_k^d . From conditions (22) and (23), we can see that if a firm draws a fixed cost $\phi_i^d(0) < \tilde{\phi}_i^d$, then in the planner problem there will be a firm entering the market. We define market failure as an event when condition (22) is not satisfied while condition (23) is satisfied.

We define the set of firms that could be a potential pioneer as E_0 . The probability of market failure could be formally defined as

$$\eta_k^d = \Pr \left[\begin{array}{l} \max_{i \in E_0} x_i < F_k^d, \\ x > F_k^d + \beta E_{x'} J(x') \end{array} \right] \quad (24)$$

This is the joint distribution of equation (22) and (23). It is obvious that

η_k^d depends on the number of entrants E_0 . The size of E_0 has a nonmonotone effect on η_k^d . One one hand, when the size of E_0 increases, it is less likely that $\max_{i \in E_0} x_i < F_k^d$, while on the other hand $x > F_k^d + \beta E_{x'} J(x')$ is more likely to happen. We utilize the average number of firms ever entered each HS6-country pair during 2000 to 2006 as a reference, which is shown in Table 10. We are going to vary E_0 to see the change of η_k^d .

7.2 Probability of Market Failure

Following section 4, we can estimate the gain of firm value $V(\Omega_i^d, \theta^d, \phi_i^d(0)) - V(\Omega_i^d, 0, \phi_i^d(0))$ and discovery cost F_k^d . A full summary of firm value and discovery cost in each sector and destination are presented in Tables 11 and 12.

product	total exporters	US/CAN	OWH	FSR	Europe	JKAZ	Asia	Africa
HS852719	1019	127	6	3	13	46	10	2
HS852713	1019	149	10	1	10	47	13	2
HS852812	1008	54	7	5	8	41	28	7
HS852530	823	78	9	1	14	43	13	3
HS852520	778	102	4	3	19	74	16	3
HS852732	542	64	7	4	5	21	7	1
HS852739	533	80	5	1	12	29	7	1
HS852731	467	38	4	5	5	10	16	9
HS852540	456	66	1	2	5	28	7	2
HS852813	352	34	3	2	5	13	6	6
HS852712	295	54	1	2	6	21	4	1
HS852692	187	36	3	2	8	21	8	4
HS852821	152	27	2	3	5	11	3	1
HS852721	130	17	1	4	2	6	2	1
HS852822	115	11	1	2	2	9	2	1
HS852691	109	21	3	2	4	10	2	1
HS852790	95	5	1	1	1	7	2	1
HS852510	61	9	1	1	1	3	2	1
HS852610	48	8	1	1	1	3	1	1
HS852729	46	4	2	2	1	2	2	1
Sample Mean	394	47	3	2	6	21	7	2
Sample Median	295	36	3	2	5	13	6	1

Table 10: Average number of entrants

	HS8525		HS8526	
	Mean	Std	Mean	Std
US, Canada	-2.92	0.39	-3.04	0.27
Other western hemisphere	-2.06	0.84	-2.15	0.89
Former Soviet Republics	-2.37	0.63	-2.42	0.92
Other European countries	-1.76	1.25	-1.69	1.75
JPN/KOR/AUS/NZL	-2.63	0.48	-2.66	0.91
Rest of Asia	-1.71	1.09	-1.81	1.10
Africa	-2.10	0.75	-2.17	0.91
	HS8527		HS8528	
	Mean	Std	Mean	Std
US, Canada	-3.29	0.23	-3.08	0.24
Other western hemisphere	-1.94	2.15	-2.09	1.27
Former Soviet Republics	-2.63	1.13	-2.48	0.74
Other European countries	-1.98	1.66	-1.84	1.41
JPN/KOR/AUS/NZL	-2.99	0.54	-2.74	0.45
Rest of Asia	-1.89	1.66	-1.86	0.97
Africa	-2.38	1.16	-2.20	0.83

Table 11: Summary Statistics of Latent Payoff

	HS8525		HS8526	
	Mean	Std	Mean	Std
US, Canada	4.13	0.31	4.00	0.32
Other western hemisphere	2.10	0.09	1.97	0.10
Former Soviet Republics	2.48	0.11	2.35	0.12
Other European countries	2.27	0.10	2.14	0.11
JPN/KOR/AUS/NZL	2.99	0.17	2.86	0.17
Rest of Asia	1.92	0.08	1.79	0.10
Africa	1.70	0.08	1.57	0.09
	HS8527		HS8528	
	Mean	Std	Mean	Std
US, Canada	3.67	0.33	3.92	0.31
Other western hemisphere	1.63	0.09	1.88	0.09
Former Soviet Republics	2.02	0.10	2.27	0.12
Other European countries	1.80	0.10	2.05	0.11
JPN/KOR/AUS/NZL	2.52	0.16	2.77	0.17
Rest of Asia	1.46	0.09	1.71	0.09
Africa	1.24	0.08	1.49	0.09

Table 12: Summary Statistics of Discovery Cost

We now reflect on the probability of market failure as a function of the potential number of entrants. At one extreme, if the number of firms is one, it is clear that there is no market failure, because the social planner's and the individual firm's optimization problems coincide ($\eta_k^d = 0$). At the other extreme, if the number of firms is infinite (and the productivity distribution is not bounded on the right, which is satisfied if productivity distribution is normal, log normal, or Pareto), then some firm is bound to get a productivity draw so high that it wants to export anyway. Therefore, the probability of market failure is likely to have an inverse-V shape. This is the limit of our intuition. How fast does the probability of market failure increase when the number of firms increases? Where does the probability peak? How fast would the probability decline after it peaks? Given a small number of entrants, when firm value is relatively larger than the fixed cost, the probability of market failure will be small since firm's maximum value will be greater than the fixed cost. On the other hand, when firm value is relatively smaller than the fixed cost, the probability of market failure will be small too since the summation of firm value is difficult to be greater than the fixed cost. When firm value is close to the fixed cost the probability of market failure will be large. We will have to use structural parameters and simulations to answer these questions.

Fix the number of entrants E_0 , we randomly draw firms to compute probability of market failure η_k^d . In Figure 3, we plot the probability of market failure in the left graph of Figure 4; we plot the probability that no firm would want to become a pioneer in a decentralized market, $(\max_{i \in E_0} V(\Omega_i^d, \theta^d, \phi_i^d(0)) - V(\Omega_i^d, 0, \phi_i^d(0)) < F_k^d)$, the probability that the social planner prefers to have a pioneer, $(\sum_{i \in E_0} [V(\Omega_i^d, \tilde{\tau}_i^d(0) \theta^d, \phi_i^d(0)) - V(\Omega_i^d, 0, \phi_i^d(0))] > F_k^d)$, and the probability that both are true simultaneously in the right graph of Figure 4. We vary the number of entrants from 1 to 500 firms. As we can see that the probability that no single firm would want to become a pioneer firms starts at a relatively high number (just below 80%), and decreases as the number of potential entrant increases. This is consistent with the notion that free-riding by follower firms becomes more severe when the number of potential free-riders increases. On the other hand, the probability that the social planner prefers to have a pioneer starts at a point just over 20%, and increases as the number of entrants increases. The probability of market failure starts at 0% (when the number of firms =1), increases first as the number of potential exporters increases all the way to about N=300, but declines afterwards as the number of potential exporters continues to increase. For all values of the number of exporters, the probability of market failure is relatively low, with the highest possible value at about 9%. In other words, in more than 90% of the cases, market failure does not occur either because some firm decides that it is worthwhile to be a pioneer in spite of spillovers, or because the social planner decides that it is not worthwhile for any export pioneering activities to occur. Therefore, in spite of clear evidence of positive discovery costs and spillover, market failure is not a high probability event in our sample.

In Figure 4, we report the probability of market failure η_k^d for all sectors and destinations. On the x-axis, we vary the size of E_0 from 1 to 200 firms. When the size of E_0 increases, the probability of market failure first rises and then declines. We see a hump shape change of η_k^d . We can see in all products, destinations' rank of probability of market failure is relatively robust. Other European countries and Rest of Asia are the destinations that decay the fastest. In these two regions, firm value is closed to the firm fixed cost.

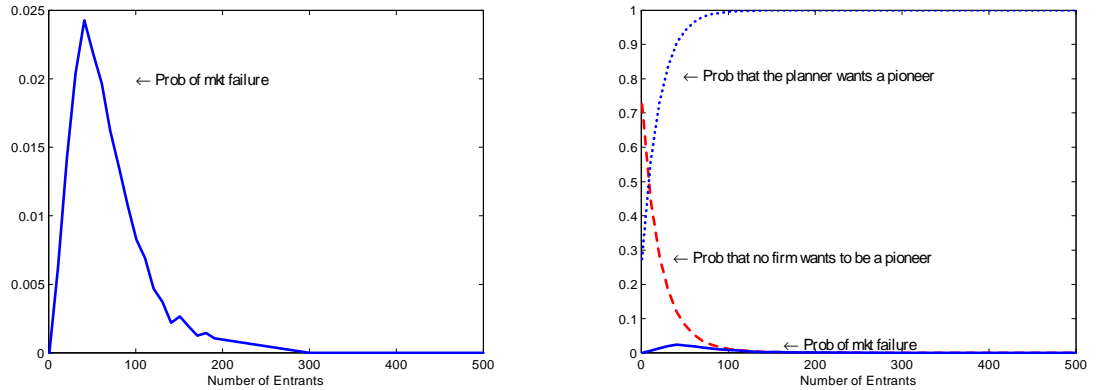


Figure 3: Prob of market failure

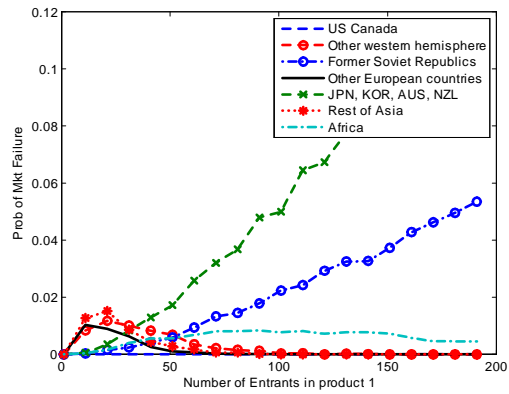
8 Extensions and Robustness Checks

We now go beyond our baseline case and explore a number of robustness checks and extensions.

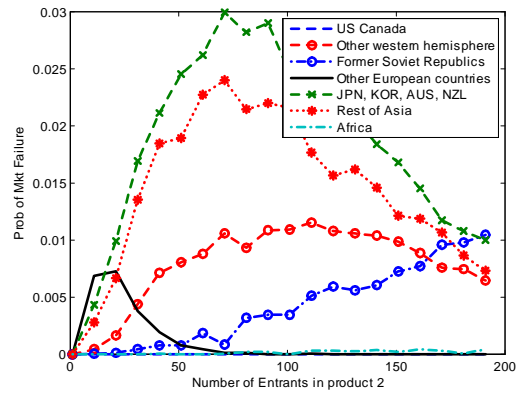
8.1 Possible Biases from Government Policies

We reflect on possible biases introduced by the use of the Chinese data.

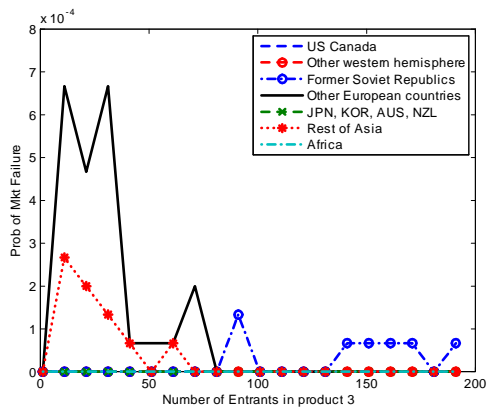
The first concern is that an undervalued Chinese currency could artificially boost export pioneering activities, resulting in a lower estimated probability of market failure. While there are frequent suggestions of an undervalued Chinese yuan during 2003-2011, data suggest that the exchange rate was not undervalued during 2000-2002, the period in which export pioneering activities take place in our sample. In Figure 5, we plot the forward Chinese exchange rate (units of Chinese yuans per US dollar) minus the spot exchange rate for both 12 months forward and 3 months forward. A positive number means that the forward market is predicting that the Chinese nominal exchange rate depreciate in the subsequent 3 or 12 months. From late 2003 to 2011, the forward spot different was always negative, indicating that the market was expecting a Chinese exchange rate appreciation. This was consistent with the expectation that the Chinese exchange rate was undervalued during that period. In contrast, until November 2002, the forward spot differential was largely positive, which suggests that the market believed that the Chinese exchange rate was over-valued and a depreciation rather than an appreciation would have to come



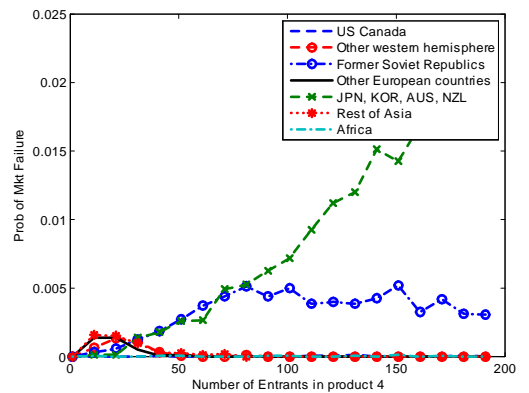
Sector 8525



Sector 8526



Sector 8527



Sector 8528

Figure 4: Prob of market failure, across four products

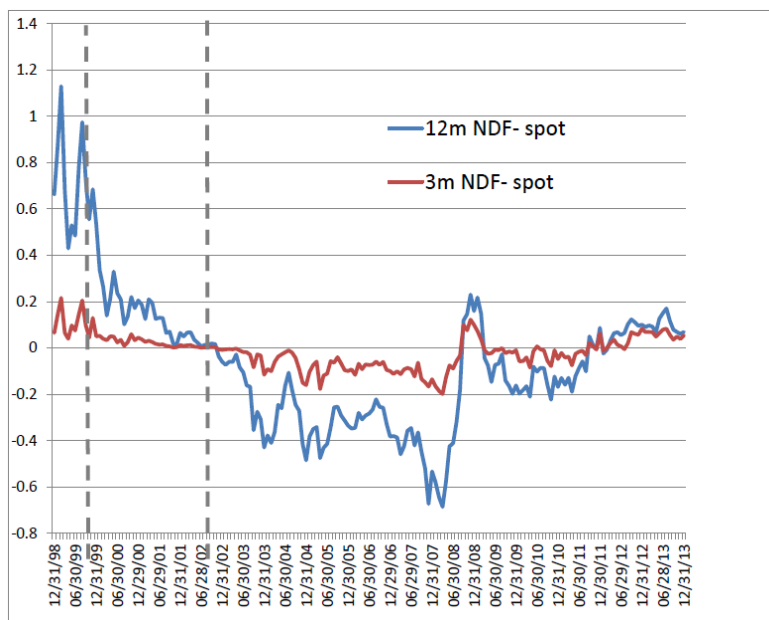


Figure 5: Prices of Non Deliverable Forwards (NDFs) Around the Time Official US Pressure Began

soon. Frankel and Wei (2007) postulate that the switch in market assessment of the Chinese exchange rate was aided by US Secretary of Treasury John Snow’s actions at a G-7 meeting in late September 2003, and Undersecretary John Taylor’s testimony before Congress on October 1, 2003.

Note that from January 1994 to July 2005, the Chinese nominal exchange rate was always fixed at 8.2 RMBs per US dollar. This means that there was no active government actions adjusting the nominal exchange rate during that period of 11.5 years. If there was exchange rate manipulation, it was done by passively neglecting to adjust the nominal exchange rate. Indeed, China did not succumb to a temptation to devalue during the Asian financial crisis of 1997-1999 as most other countries in Asia did, and was praised by the United States and others for not changing its nominal exchange rate (Frankel and Wei, 2007). If one takes the position of currency manipulation, one would have to say that the real exchange rate was manipulated to discourage exports during 1994-2002 before it was switched to encourage exports during 2003-2011. In any case, using the forward market as a guide, the Chinese exchange rate was likely over-valued during 2000-2002, which should bias against finding a low probability of market

failure.

The second concern is that export subsidies by the Chinese government may also boost export pioneering activities, resulting in a lower observed frequency of market failure. There is no shortage of Chinese trading partners alleging Chinese export subsidies. During 2004-2010, there were a total of 43 countervailing duty cases (i.e., cases alleging illegal export subsidies) at the WTO against Chinese exporters involving 47 four-digit sectors, or 71 case-sector pairs. (Note that each case may contain multiple sectors, and a given sector may be involved in multiple cases.) There were no CVD cases against China before 2004. Six sectors were most frequently targeted. They are HS7306 (tubes, pipes and hollow profiles, 8 cases), HS7304 (seamless tubes and pipes, 5 cases), HS7604 (aluminum bars, rods and profiles, 3 cases), HS8418 (refrigerators, freezers and heat pumps, 3 cases), HS4810 (paper and paperboard, 3 cases), and HS7608 (aluminum tubes and pipes, 3 cases). Importantly for this study, none of the four sectors used in our sample has ever been subject to CVD lawsuits. That is, no country has ever complained to the WTO of illegal export subsidies in Chinese exports of HS8525-8528. In fact, it is relatively uncommon for any of the 48 sectors in Chapter 85 to be subject to CVD cases. Only three sectors in this chapter, HS8505 (electromagnets and permanent magnets), HS8516 (electric heaters for water, space and soil), and HS8517 (electric apparatus for telephone sets) were ever subject to a CVD case, each involving a single complaint country, accounting for 6.4% (3/47) of the sectors or 7.3% (3/41) of the cases ever subject to CVD cases. We therefore conclude that export activities in our sample were unlikely to have been boosted by government export subsidies.

Chinese exporters face more antidumping cases than CVD cases. Most antidumping cases do not involve government export subsidies; many may be judged to be protectionist in nature for a fair-minded economist. Indeed, China's WTO accession agreement was written in such a way that it was relatively easy for a trading partner to impose antidumping duties on Chinese exporters (Bown, 2005). We can take a very conservative approach and regard each antidumping case as potentially involving export subsidy. During the period, 2000-2010 there were 707 antidumping cases against Chinese exports involving 351 four-digit sectors. Only once was one of the sectors in our sample (HS8528 "color television receivers") was subject to an antidumping law suit (which was lodged by the United States in 2003). In that case, the US International Trade Commission

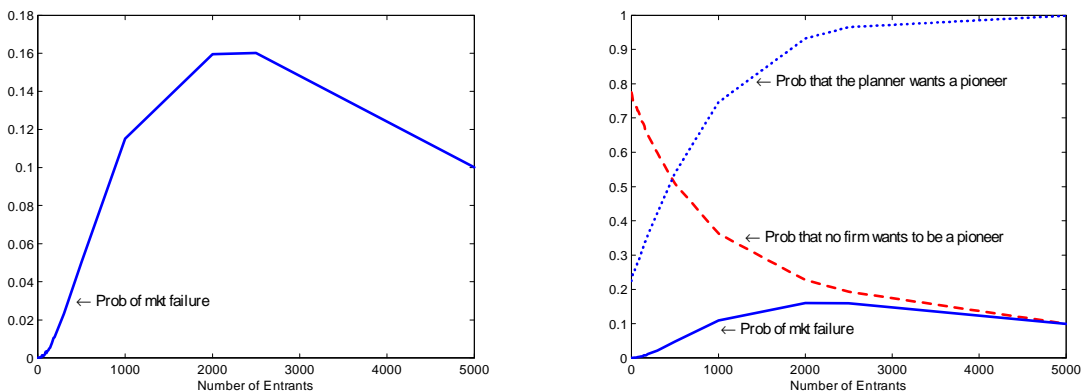


Figure 6: Prob of market failure, shutting down FMA

eventually imposed an antidumping duty of 78.45% to Chinese TV exporters⁹. In the results reported earlier (Figure 4), we see that we would have reached the same conclusion of a relatively low probability of market failure if we had only focused on the estimates for the other three sectors.

8.2 Shutting Down FMA

We try to shut down the FMA in this section. In the benchmark case, we assume pioneer firms have a larger market share at the beginning and then gradually decay to 0. Now we assume in the demand equation (4), $\theta = \lambda = 0$. Hence pioneer firms do not have any advantage at the beginning. The probability of market failure is as figure 6. The peak probability is higher than the baseline model, about 16% while the slope of the curve is smaller.

8.3 Dropping Smaller/Poorer Economies

In the baseline estimation, we assume that the parameters are the same for all countries within a given region (in order to reduce computation burden). However, the probability of market failure could be either higher or lower for richer/larger countries than for poorer/smaller ones. On the one hand, exploratory activities may be more costly in a larger or richer economies (e.g., due to higher costs of advertisement or hiring of a consultant), implying a higher

⁹http://www.usitc.gov/trade_remedy/731_ad_701_cvd/investigations/2004/color_television_receivers_from_china/final/PDF/fr_commerce_order.pdf for details

probability of market failure. On the other hand, costs of dealing corruption and regulatory barriers could be lower in more developed economies, implying a lower probability of market failure. To formally link the size of the discovery cost to a country's size, income level and other characteristics, and allow them to vary by sector and regions, would add many more parameters. This would increase the computational time substantially. Instead, we re-estimate the model on two smaller samples and compare the results with our baseline case.

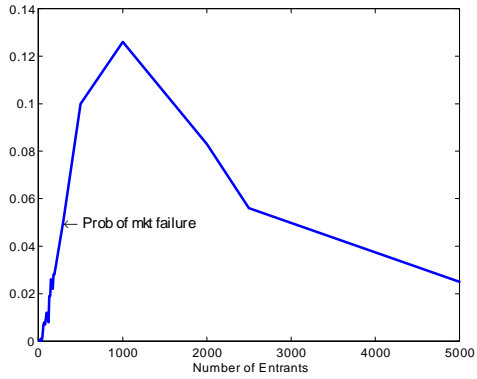
Our first sample variation is to drop countries with less than 1 million people in 2000. This reduces the number of newly conquered markets (product destination pairs) during 2000-2002 from 593 markets involving 157 countries in the baseline case to 509 markets involving 134 countries. Our second sample variation is to drop all countries with either less than 5 million people or with per capita income less than US\$500 in 2000. In the reduced sample, the number of newly conquered markets shrinks further to 299 product destination pairs involving 71 countries.

We estimate the model for each of the reduced samples, and report the results in terms of the probability of market failure in Figure 7. While the peak probability of market failure tends to be higher than the baseline case, at the 13% and 22%, respectively, they are still low in some absolute sense. Comparing these results with the baseline case, it appears that the probability of market failure tends to be a bit higher when we restrict our attention to richer and larger markets.

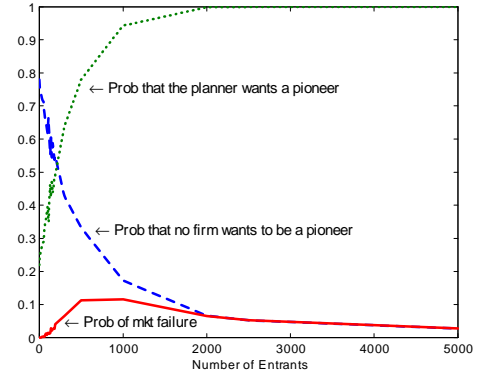
8.4 Sample Variations by Dropping or Adding a Sectors

In this subsection, we explore the robustness of our results to some perturbations of our sample. We try the following five perturbations?: taking each of the 4-digit sector one by one and re-estimate the model based on a sample with the remaining three sectors, and adding a new 4-digit sector (HS8524).

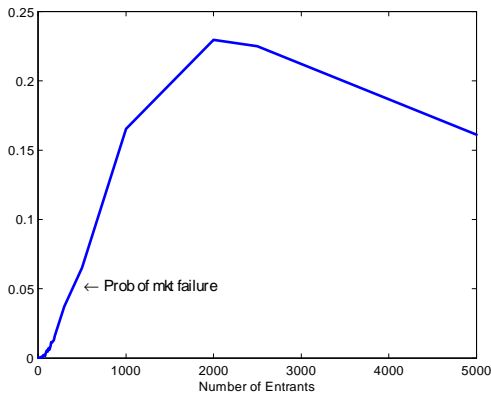
For each perturbation, we trace out the probability of market failure as a function of the potential number of exporters. We report all five lines in Figure 8. Since the mean and median number of exporters are 394 and 295, respectively (Table 15), we conclude that the probability of market failure is not high in practice.



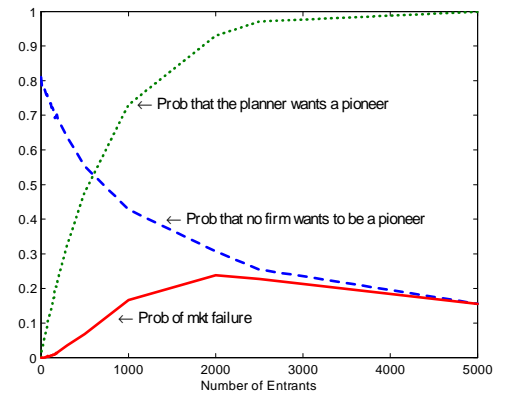
Markets above 1 million population



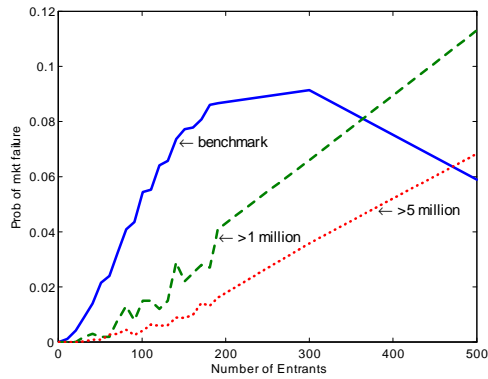
Markets above 1 million population



Markets above 5 million population and income above 500USD



Markets above 5 million population and income above 500USD



Prob of market failure 41

Figure 7: Prob of market failure, large markets

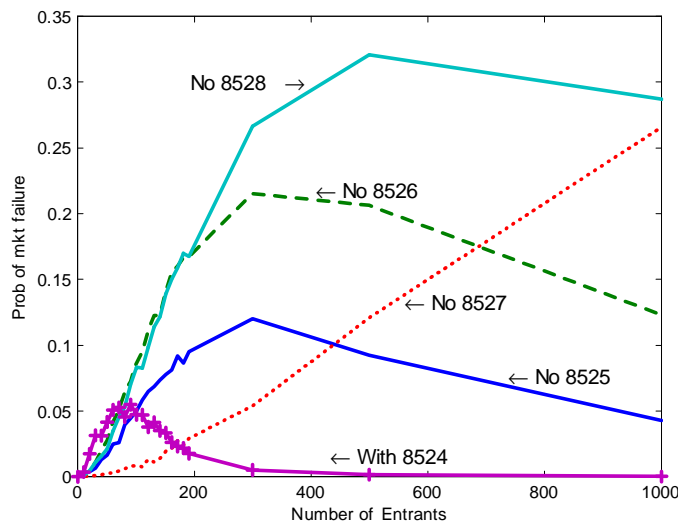


Figure 8: Prob of mkt failure after dropping or adding an industry

8.5 Additional Learning Channels

In the benchmark case, we assume there is only one learning channel - followers can learn from pioneer firms in the same product destination pair. In this subsection, we broaden the set channels a firm can learn about export viability. In particular, we allow four additional learning channels, to be captured by four additional parameters that are related observable firm characteristics $w_i(t)$ in equation 6. The first is a firm's own export value of different products to the same destination in period $t-1$, which captures learning from one's own exports to the same destination. Albornoz et. al (2010) explores this idea. The second is a firm's own export value of same products to different destinations in period $t-1$, which captures learning from exports of same products regardless of destinations.

Besides learning from the firm's own export experience, we also explore the learning from other firms. Fernandez and Tang (2012) study the spillover effects of other exporters on new exporters. Therefore, our third new learning channel is through other firms' total exports of different products to the same destination in period $t-1$. The fourth learning channel is through other firms' export value of the same product to different destinations in period $t-1$. These modifications also change the probability of export in equation 12. The set of state variable

Parameters	mean	std	significance
Own same goods Export history	0.17	0.03	*
Own same destination Export history	1.27	0.03	*
Others same goods export history	0.04	0.01	*
Others same destination export history	-0.38	0.17	*
SOE	-0.13	0.08	*
JV	4.59	3.73	
FIE	5.79	3.86	
Local wage	5.30	3.80	
Processing status	6.71	4.17	
Preference shock	-0.16	0.03	*
Productivity shock	0.24	0.04	*

Table 13: Follower Participation Equation, with learning assumptions

Ω_i^d now includes these four additional variables¹⁰.

In Table 13, we report our estimation on firm export participation equation, and Table 14 reports the effects on pioneering equation. We find evidence that firms do learn both from their own export experiences and from other firms' export experiences. A firm's export probability is higher if it has exported other products to the same destination before, or if other firms have exported the same products to other destinations before. However, we do not find statistically significant evidence for learning from a firm's own export history of the same product to other destinations. In fact, the estimate appears to suggest that the latter could discourage one's export participation in new markets. This is probably due to that the opportunity cost to enter new market is high when firms producing the same product have other destination options.

Using the expanded set of structural parameters, we re-compute the probability of market failure and present it in figure 9. As we can see, once we allow for additional learning channels, the probability of market failure shrinks further to 1.5% or lower.

¹⁰We keep equation (4) same and change the equation (6) by augmenting $w_i(t)$. Hence $w_i(t)$ includes not only firm's ownership and local wage but also four new variables that captures learning from own experience and learning from other firms. Then equations (12) and (13) are also changed since state variables Ω_i^d are augmented too.

parameter	mean	std. dev	significance
Discovery cost: US/Canada	Benchmark		
Discovery cost: Other western hemisphere	-106.9	32.33	*
Discovery cost: Former Soviet Republics	-3.92	1.64	*
Discovery cost: Rest of Europe	-364.5	108.8	*
Discovery cost: JPN/KOR/AUS/NZL	-221.5	66.05	*
Discovery cost: Rest of Asia	-285.8	85.47	*
Discovery cost: Africa	-60.62	18.7	*
Discovery cost: HS8525	-3103	920.8	*
Discovery cost: HS8526	-3103	920.7	*
Discovery cost: HS8527	-3102	920.7	*
Discovery cost: HS8528	-3103	920.7	*
Own same goods Export history	0.02	0.01	*
Own same destination Export history	0.07	0.01	*
Others same goods export history	-0.02	0.02	
Others same destination export history	141.7	42.09	*
SOE	-0.02	0.09	
JV	-0.57	0.17	*
FIE	-0.82	0.15	*
Local wage	-0.34	0.14	*
Processing status	6.76	1.08	*
Preference shock	-0.09	0.05	*
Productivity shock	-0.12	0.03	*

Table 14: Pioneering Equation, with learning assumptions

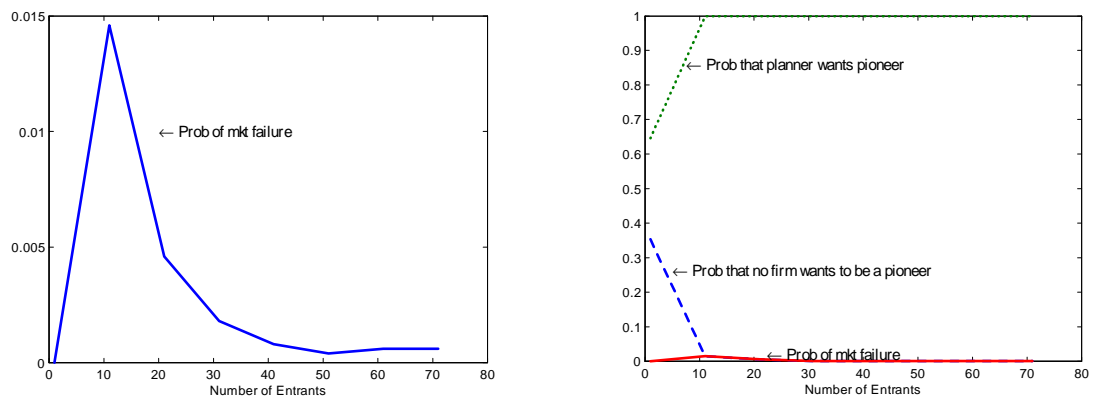


Figure 9: Prob of market failure, under different learning assumptions

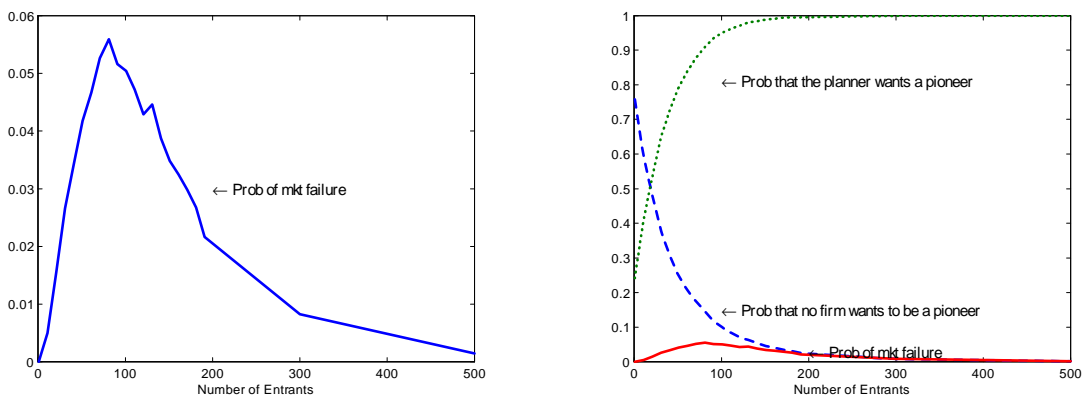


Figure 10: Prob of market failure, no intermediary firms

8.6 Intermediary Firms

Intermediary firms are firms that specialize in exports and imports, and may not be a producer themselves. They play an important part in facilitating trade (Ahn, Khandelwal and Wei, 2011). It is natural to ask whether they have helped to reduce the probability of market failure. Data show that around 20% of Chinese export transactions or 2% of the export value in sectors 8525-8528 during 2000-2006 were carried out by intermediaries. Because we do not live in a world without intermediary firms, we cannot formally estimate the probability of market failure in a world without intermediaries.

We can gauge the importance of intermediary firms in export pioneering activities in the following way: we focus on a subsample with direct producers only. More specifically, we exclude those new markets where the first exporter is an intermediary firm, and pretend intermediary firms do not exist even if they are follower firms. With these modifications, we re-compute the probability of market failure and report it in Figure 10. As we can see, without giving credit to intermediary firms in conquering new markets, the probability of market failure tends to be moderately higher than the baseline case when the number of potential exporters is less than 100 but tends to be lower when the number of exporters becomes bigger. In any case, the probability of market failure is not too high in an absolute case. Since intermediary firms can be formed with market forces, even a high probability of market failure in the absence of intermediaries would not be a solid base for government actions.

Common Market	Regions
Caribbean Common Market (CARICOM)	Other western hemisphere
Central American Common Market (CACM)	Other western hemisphere
Common Market for Eastern and Southern Africa (COMESA)	Africa
European Community (EC)	Rest of Europe
Southern Common Market (MERCOSUR)	Other western hemisphere

Table 15: Common markets in the year of 2000

8.7 Common Markets

We have defined a market as a pair of a 6-digit product and a country. However, some countries have formed a customs union or a common market. As Table 15 shows, there are five common markets during our sample period of 2000-2002¹¹. Members within these common markets enjoy free trade and sometimes free movement of labor and capital; they also maintain a common set of tariffs and customs regulations against imports from non-member countries. One could make a case for assuming that only one discovery cost needs to be paid to enter any member country. Once an exporter reaches one member country, it can costlessly reach all other member countries in the same customs union.

We now investigate the consequence of this assumption for our main conclusion. Specifically, we treat a common market as a single destination country and re-identify markets accordingly. With this new definition of destinations, 444 new markets were conquered during 2000-2002. We re-estimate the structural model, re-compute the probability of market failure, and report the main results in Figure 11. Compared to the baseline case, we find that this extension also tends to result in a lower probability of market failure.

¹¹Member countries of CARICOM include Antigua, Barbuda, the Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad, Tobago.

Member countries of CACM include Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua.

Member countries of COMESA include Angola, Burundi, Comoros, Democratic Republic of the Congo, Djibouti, Egypt, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Namibia, Rwanda, the Seychelles, Sudan, Swaziland, Uganda, Tanzania, Zambia.

Member countries of EC include Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, the UK.

Member countries of MERCOSUR include Argentina, Brazil, Paraguay, Uruguay.

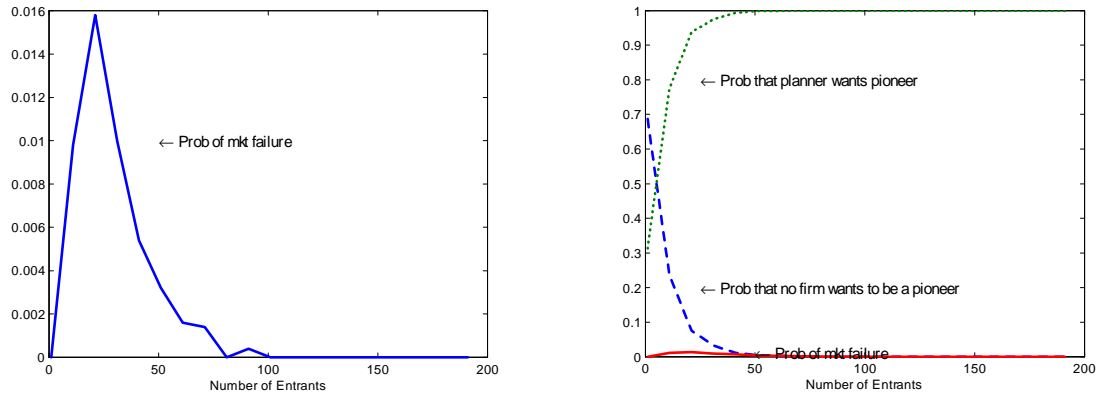


Figure 11: Prob of market failure, common markets

8.8 Market Failure in Exporting Brand New Products

The analysis so far has focused on possible market failure in discovering new markets when firms export existing products to new destinations. A different type of discoveries involves firms exporting brand new products to the world market. We now make an attempt at gauging the likelihood of market failure in this type of export pioneering activities in the manufacturing sector. First, we estimate the set of manufacturing goods in which China may have potential comparative advantage by 2002 based on the export bundles of both China and other similar countries. Second, we compute the fraction of such goods that China did not export during 2000-2002.

For the set of countries similar to China in 2002, we look at all countries whose per capita income is within (-20%, +50%) of the Chinese level in that year. There are 20 such countries: Kazakhstan (\$1658), Tuvalu (\$1621), Kosovo (\$1587), Cabo Verde (\$1480), Belarus (\$1479), Samoa (\$1454), Albania (\$1363), Morocco (\$1363), Vanuatu (\$1354), Egypt Arab Rep (\$1286), Syrian Arab Republic (\$1270), Honduras (\$1197), Paraguay (\$1135), Swaziland (\$1131), Philippines (\$1005), Nicaragua (\$995), Turkmenistan (\$970), Guyana (\$962), Congo Rep (\$920) and Indonesia (\$910). The Chinese per capita income in 2002 was \$1135.

For each country on the list, we consider each of their 6-digit manufacturing export products as a potential comparative advantage product for China. Note that HS 6 digit is the most disaggregated product classification that is common across countries. By this method, the set of “similar countries” jointly export

4084 products (out of a total of 5110 manufacturing products). This is a set of products that countries similar to China collectively show a revealed comparative advantage. Let us call this set A. (We use the term "revealed comparative advantage" more broadly than the traditional usage as our goal is to catch the set of products that China could be exporting.)

During 2000-2002, China exported a total of 4125 manufacturing products, which constitute a set of revealed comparative advantage products for China. Let us call this set R. The two sets of products do not overlap perfectly. In fact, there are 100 products that the set of "similar countries" exported but China did not. Let us call this set M. We might define R+M as the set of goods that China has potential comparative advantage; that is, these are the goods that China or a country with its level of income could conceivably export. R+M=4225.

Some of the products in M may not reflect market failure because China may have no genuine comparative advantage in them. But if we err on the side of capturing the upper bound of market failure and regard all goods in M as reflecting market failure, the probability of market failure in exporting brand new products is $M/(R+M) = 100/4225 = 2.4\%$.

Not all products in M are equally important in the export bundles of the "similar" countries. Judging by the export value in 2002, the top 10 products in M are: 854219 "Monolithic digital integrated circuits", 710812 "Gold in Other Unwrought Forms", 482359 "Other paper and paperboard", 481012 "Paper and paperboard of a kind used in ...", 710813 "Gold in Other Semi-manufactured Forms", 410410 "Whole bovine skin leather", 440320 "Other coniferous tropical woods", 854214 "other Monolithic digital integrated circuits", 560730 "Other Hard Fibres", and 410421 "Other bovine leather". If interventions are deemed desirable, these are presumably some of the potential export items that firms can be encouraged to look into. Note that XXX number of these products are exported by three or less countries; they might not represent genuine potential comparative advantage products for China.

Overall, the probability of market failure in exporting brand new products appears low for China. Nonetheless, it is possible that the probability is much higher for smaller economies or at a product level that is more disaggregated than HS 6 digit.

9 Concluding Remarks

The paper aims to assess the empirical plausibility of a highly cited hypothesis in the international trade literature, namely export pioneering activities are prone to market failure. Existing empirical papers tend to focus on documenting that discovery of a new market is costly and that knowledge spillover to follower firms exists. We recognize that a positive discovery cost and spillover are necessary but not sufficient for the existence of market failure. For market failure to occur, two inequalities would have to hold simultaneously. No existing paper in the literature has formally assessed the empirical likelihood of these inequalities. Our goal is to employ a structural estimation approach to perform such an assessment.

We confirm the existence of a positive discovery cost and spillover in export pioneering activities. We also find evidence supporting the existence of a first mover advantage (FMA) in the export context. While the notion of FMA is widely discussed in the industrial organization literature, it surprisingly has not been featured in the theoretical or empirical literature on possible market failures in export pioneering activities. In any case, the main contribution of the paper is to use structurally estimated parameters to formally assess the likelihood of both inequalities. We find that the probability of market failure is generally not very high in spite of its theoretical plausibility. This conclusion appears robust in a number of extensions and checks we have examined.

We note our conclusion applies to exporting pioneering activities related to taking an existing product to new destinations. It is possible that market failure is more likely when pioneering activities are pertaining to taking a brand new product to the world market. While our back-of-envelope calculations do not support this, we leave a more rigorous examination of this question to future research.

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10 Appendix

10.1 Estimation Procedure

Denote the parameters in demand equation (4) as $n = (\alpha^d, \rho, \lambda, \theta^d)$ and parameters in pricing equation (7) as $m = (\gamma^d, \gamma_k, \gamma(t), \gamma_{kw})$. Then the parameters that need to be estimated is $\Theta = (n, m, \Sigma, \psi)$. At the start of simulation round s , estimation results in step $s - 1$ is denoted as $n^{s-1}, m^{s-1}, \Sigma^{s-1}, \psi^{s-1}$. And unobserved firm shock is denoted as $(\omega^{s-1}, \xi^{s-1})$ and their joint distribution parameters as b^{s-1}, W^{s-1} . Then we update our estimation in the following way:

- (1) Conditional on ξ^{s-1} , we can estimate n^s from demand equation (4)

$$\ln \frac{s_i^d(t)}{s_0^d(t)} - \xi_i^{d,s-1} = -\alpha^d \ln p_i^d(t) + \rho I_i^d(t-1) + I_i^d(0) (\theta^d - \lambda t) + u_i^d(t)$$

- (2) Conditional on $n^s, \xi^{s-1}, \omega^{s-1}$, we can update m^s from pricing equation (7)

$$\ln p_i^d(t) - \ln \left(\frac{\alpha^d}{\alpha^d - 1} \right) - \omega_i = \gamma^d + \gamma_k + \gamma(t) + \gamma_{wk} \bar{w}_i(t) + v_i^d(t)$$

- (3) We get residual terms $u_i^{ds}(t), v_i^{ds}(t)$ from step 1 and 2, and then update after estimation of Σ^s

- (4) Define the latent payoff if firm exports (including pioneer decision)

$$V_i^{de}(t) - \phi_i^d(t) - V_i^{dn}(t) = H \left[\xi_i^d, \alpha^d \omega_i, \bar{w}_i(t), I_i^d(0) (\theta^d - \lambda t), I_i^d(0) = 1, \bar{Y}_k^d(t); \psi \right]$$

$$\tilde{V}_i^{de}(t) - \phi_i^d(t) - \tilde{V}_i^{dn}(t) = \tilde{H} \left[\xi_i^d, \alpha^d \omega_i, \bar{w}_i(t), I_i^d(t-1), I_i^d(0) = 0, \bar{Y}_k^d(t); \psi \right]$$

$$V_i^{de}(0) - \phi_i^d(0) - \tilde{V}_i^{dn}(0) - F_k^d = H_x \left[\xi_i^d, \omega_i, \bar{w}_i(0), \bar{Y}_k^d(0); \psi \right]$$

Conditional on $n^s, m^s, \omega^{s-1}, \xi^{s-1}$ and Σ^s then draw ψ^s using

$$\prod_{d,t} G \left[\bar{\phi}_i^d(t); \Theta \right]^{I_i^d(t)} \left[1 - G \left(\bar{\phi}_i^d(t); \Theta \right) \right]^{1-I_i^d(t)} G \left(\tilde{\phi}_i^d; \Theta \right)^{I_i^d(0)} \left[1 - G \left(\tilde{\phi}_i^d; \Theta \right) \right]^{1-I_i^d(0)}$$

- (5) Update ω^s, ξ^s using a Gibbs sampling procedure: draw ω^s, ξ^s from a

normal distribution with parameters b^{s-1}, W^{s-1} . Accept the new draws with probability

$$p = l(D_f | \Theta, \xi, \omega)$$

(6) Then we update estimation of b^s, W^s using new ω^s, ξ^s .

(7) After a large number of simulations, compute $A_i = \pi_i^d(0) + \beta E_\phi V(\Omega_i^d(1), \phi_i^d(1))$,
 $B_i = \beta E_\phi V(\Omega_i^d(1), \phi_i^d(1))$, $A'_i = \pi_i^d(1) + \beta E_\phi V(\Omega_i^d(2), \phi_i^d(2))$ and $B'_i =$
 $\beta E_\phi V(\Omega_i^d(2), \phi_i^d(2))$

(8) Guess F_k^d, χ

(9) Guess $\bar{V}(A_i, B_i, \phi_i)$, then iterate on value function until convergence

$$\bar{V}(A_i, B_i, \phi_i) = \max \{A_i - \phi_i - F_k^d, \chi B_i + (1 - \chi) \beta E_\phi \bar{V}(A'_i, B'_i, \phi'_i)\}$$

(10) Compute $\tilde{\phi}_i$ and then compute χ iterate until it converges

(11) Solve F_k^d by using average latent payoff is the same.

10.2 Generate a counter example to test the code

We simplify the model by assuming that firms draw preference and productivity shock from $f(\xi, \omega)$. We assume $\rho = 0$ and then the market share is assumed to follow

$$\ln \frac{s_i^d(t)}{s_0^d(t)} = \delta_i^d(t) = \xi_i^d - \alpha^d \ln p_i^d(t) + I_i^d(0)(\theta^d - \lambda t) + u_i^d(t)$$

Assume we can not observe any firm characteristics $\vec{w}_i(t)$, then

$$\ln c_i^d(t) = \omega_i + v_i^d(t)$$

$$\ln p_i^d(t) = \ln \left(\frac{\alpha^d}{\alpha^d - 1} \right) + \omega_i + v_i^d(t)$$

Given the aggregate demand as $Y_k^d(t) = \frac{M_k^d(t)}{\sum_j \exp(\delta_j^d(t))}$, then firm's expected static profit is

$$\pi_i^d(t) = E_{u,v} \left[\exp(\delta_i^d(t)) Y_k^d(t) \frac{1}{\alpha^d} p_i^d(t) \right]$$

Since we assume $\rho = 0$, hence firm decision now is a static decision. Firm

will export iff $\pi_i^d(t) > \phi_i^d(t)$. Hence the cutoff value of export now is

$$\ln [\pi_i^d(t)] = \ln \left(\frac{1}{\alpha^d} \right) + \ln \bar{Y}_k^d(t) + \ln \bar{r}_i^d + \ln b_i^d(t)$$

where

$$\begin{aligned} \ln \bar{Y}_k^d(t) &= \ln Y_k^d(t) + (1 - \alpha^d) \ln \mu^d + C_{uv} \\ C_{uv} &= \ln E_{u,v} [\exp(u_i^d(t) + (1 - \alpha^d) v_i^d(t))] \\ \ln \bar{r}_i^d &= \xi_i^d + (1 - \alpha^d) \omega_i \\ \ln b_i^d(t) &= I_i^d(0) (\theta^d - \lambda t) \end{aligned}$$

Then expected profit is

$$x_t = E_\phi \max(\pi_i^d(t) - \phi_i^d(t), 0) = \int_{-\infty}^{\pi_i^d(t)} (\pi_i^d(t) - \phi) f(\phi) d\phi$$

We use x_t^P, x_t^F to denote profit of pioneer and follower firms.

Then we have follower firm value at the beginning is

$$V_0^F = \sum_{t=1}^T \beta^t x_t^F + \beta^{T+1} V_{T+1}^F$$

Pioneer firm value is

$$V_0^P = \pi_i^d(0) - \phi_i^d(0) + \sum_{t=1}^T \beta^t x_t^P - F_k^d + \beta^{T+1} V_{T+1}^F$$

Market failure is defined as

$$\max V_0^P < V_0^F, \sum V_0^P > 0$$

It means that

Given parameters Θ , we solve x_t and then we get V_0^F . We adjust F_k^d to get a sample where market failure is large. Then given this sample, we use our model to estimate.