Assessing Market Failures in Export Pioneering Activities: A Structural Estimation Approach *

Shang-Jin Wei
Asian Development Bank

Ziru Wei
Tsinghua University

Jianhuan Xu
New York University

August 10, 2014

Abstract

The paper provides a first structural-estimation-based assessment of an influential hypothesis that export pioneers are too few relative to social optimum due to knowledge spillover in new market explorations. Such market failure 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 has to hold in the data. We estimate the structural parameters based on the customs data of Chinese electronics exports. While we find positive discovery cost and spillovers, "missing pioneers" are nonetheless a low probability event.

*We thank Wouter Dessein, Amit Khandelwal, Nikhil Patel, Andrea Prat, Daniel Xu, and seminar participants at the NBER China workshop, Columbia University, USC, Tsinghua University, and SHUFE for helpful discussions, and especially Daniel Xu for generously sharing his codes with us, and Nikhil Patel and Lea Sumulong for editorial comments. All errors are our responsibilities.

1 Introduction

Using a structural estimation approach, this paper aims to gauge the empirical plausibility of an influential hypothesis that export activities are prone to a particular type of market failure, namely, due to knowledge spillovers from the first successful exporter to follower firms, there are too few export pioneers relative to social optimum.

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, it has been argued that "missing pioneers" are particularly likely. 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, export pioneering activities may be less 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), missing export pioneers and under-exporting may contribute to economic under-development. Many have cited this possibility as a basis for supporting government interventions, 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 1150 citations by Google Scholar count.

Several recent empirical papers provide support for elements of this hypothesis. Freund and Pierola (2010) examine 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 intervention via a US foreign aid program. The case study supports the notion that a country's latent comparative advantage needs to be discovered 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 was somewhat random, and there was 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, the problem of missing pioneers was avoided. Nonetheless, one may be tempted to think that such market failure can happen in many other cases. Indeed, the literature in general appears to accept the market failure argument. To our knowledge, no paper so far has concluded formally that "missing pioneers" are a low-probability event.

However, the existence of costly discovery and positive externality do not automatically imply missing pioneers and a need for government intervention. Such market failure 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 the full 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 look at the empirical evidence on these inequalities. As far as we know, no existing empirical work has taken the approach of assessing both inequalities simultaneously. Hence, we are not yet able to judge if "missing pioneers" are a high probability event or not.

In addition, a different type of market failure may arise that goes in the opposite direction of "missing pioneers." Sometimes, the social planner may prefer that no firm enters a particular export market in that period and all firms wait for at least one more period before entering a new market but some firms want to do it right away anyway. For example, based on the knowledge about the distributions of the shocks, the social planner may decide that the realization of the shocks in the next period is likely to be more favorable in expectation and the sum of the firms' expected profits could be larger if all firms defer their decisions on being a pioneer to the next period. However, a would-be pioneer this period may not want to wait and risk losing potential first-mover-advantage (FMA) to another firm in the next period. This could produce "premature or too many pioneers." While such a possbility is not entertained in the Hoff (1997) and Hausmann and Rodrik (2003) models, both types of market failure can be investigated in a unified framework.

In this paper, we develop a structural estimation framework to study these questions. We apply the framework to micro-data on Chinese electronics products (e.g., cameras, radios, radars, and television sets). Specifically, 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 customs data to capture all new market explorations during 2000-2002, 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 structural parameters including the discovery costs, 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 unit export values evolve over the sample period. Armed with these structural parameters, we then make assessments on the likelihood of both types of market failures.

To preview the main results, we find positive costs of discovery, evidence of knowledge spillover from export pioneers to follower firms, and evidence of first mover advantage. Most importantly, in spite of the existence of positive knowledge spillover, we discover that the probability of "missing pioneers" is generally not very high. One reason for this result is that productivity (and demand) shocks are sufficiently dispersed across firms in reality such that the probability that no firm wants to be a pioneer is low. On the other hand, the probability of "premature or too many pioneers" is at least as high as that of "missing pioneers."

While our paper shares some common features with the existing literature by allowing for both discovery cost and knowledge spillover, it differs in four important ways. First, we introduce FMA. This is likely to reduce the likelihood of missing pioneers. (Note that we allow for but do not impose FMA.) Second, we use structural estimation to uncover parameter values rather than reduced form regressions or case studies. Third, we provide the first-ever assessment of the likelihood of "missing pioneers" (the percentage of product-destination pairs for which both inequalities hold). Fourth, we examine both types of market failures, not just "missing pioneers." Our conclusion is also different from the existing literature - our results suggest that "missing pioneers" are not a high probability event in spite of its theoretical plausibility and our empirical confirmation of knowledge spillovers.

The rest of this paper is organized as follows. In Section 2, we review a larger body of the literature and comment on the contributions of our paper. 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. We also contrast the social planner's solution with the decentralized market equilibrium. In Section 4, we explain the procedure and techniques used to estimate this non-linear problem with a large number of parameters. We also 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 questions. In Section 5, we present our baseline estimation results, including estimates for discovery costs and FMA. In Section 6, using the structural parameter estimates, we provide an assessment of the probability of "missing pioneers" and that of "premature pioneers". In Section 7, we discuss a number of extensions and robustness checks. Finally, in section 8, we provide concluding remarks.

2 Placing the Paper in Broader Literatures

This paper is related to a larger literature on informational barriers to trade. Besides Hoff (1997) and Hausmann and Rodrik (2003), Wagner and Zahler (2011) propose 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 the Melitz (2003) model (see also evidence in Bernard et al., 2007, and Freund and Pierola, 2010) in which firm productivity is a key determinant of whether a firm would export or not and how much to export. In the model we will present, we allow both forces to play a role and rely on the data to decide on their relative strength. In particular, a permanent component of firm-level productivity will give the more productive firms an edge in the export decision, other things equal. However, other things are not held equal as all firms are assumed to face a random fixed entry cost to an export market and a transitory component in both productivity and demand. The latter assumption is motivated by the work of Wagner and Zahler (2011). 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.

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

We have already noted that several empirical papers have cited the theoretical models and provided empirical support for parts of the story. Prominent empirical papers include Freund and Pierola (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 demonstrate 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. Fernandes and Tang (2014) provide both a model and evidence from China that exporting firms learn about a foreign market from the successes and failures of other firms. When they test if a firm learns more from a nearby firm than from another domestic firm that is farther away, they find no evidence that distance matters in this case. Why is this the case? If trade associations, trade shows, and industry conferences at the national level are the primary channels for information spillover, then distance may matter much less in this case.

We can connect the current discussion on costs of discovering a new market to another literature that features 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) show that information about a foreign market is costly. Just as important, they also show that firms often tap into social networks or organize themselves in ways to overcome the informational barriers. In other words, new explorations can successfully take place in markets where information appears costly even in the absence of government interventions. This makes "missing pioneers" less likely than it first appears.

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 gravity 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) shows 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, a government's role may not necessarily be about reducing informational barriers. It could include reducing financing difficulties of exporting firms or applying political pressures on a foreign government to re-direct trade flows away from other trading partners. In other words, they are not a direct support of the "missing pioneers" hypothesis.

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 addition, none of the papers on this topic has simultaneously examined both the possibility of too few pioneers and that of too many pioneers. In this sense, our paper fills an important void in the literature.

3 Theoretical Model

We now develop a dynamic structural model for a firm's decision on whether it wants to be a pioneer, a follower, or a non-exporter. In the baseline model, a firm is assumed to produce a single product, and has to make an entry, stay, or exit decision in every market in every period. (In our empirical estimation, we call each HS 6-digit line a product, each HS 4-digit line a sector, and each individual country a destination. A market is a product-destination pair.)

Our model ultimately produces a system of four equations: (a) a demand function, (b) a cost function, (c) for a firm in a mature market, a decision rule on whether to export to the market, and (d) for a firm in a previously unexplored market, a decision rule on whether to become a pioneer. Because the last two equations are non-linear, a general model may have too high a dimension to be estimated. We will impose restrictions on the parameters so that the number of parameters is more manageable.

3.1 Demand

We begin with the demand curve for an individual firm that produces product k. With slight abuse of notation, we use i to denote both an individual firm and the variety that the firm produces. The demand for firm i's variety in destination d at time t is denoted as

$$\ln s_i^d\left(t\right) = \delta_i^d\left(t\right) + \ln Y_k^d\left(t\right)$$

where $\ln Y_k^d\left(t\right)$ is an aggregate demand shifter for product k in destination d and time t and $\delta_i^d\left(t\right)$ is a shifter that is specific to the firm's variety. We will specify the demand in such a way as to capture the possibility of FMA. FMA refers to the possibility that the demand for the first exporter's variety is higher than that for those of other firms, but this advantage could be eroded over time. More precisely, we model the firm-specific term $\delta_i^d\left(t\right)$ as:

$$\delta_i^d\left(t\right) = \xi_i^d - \alpha_k^d \ln p_i^d\left(t\right) + I_i^d\left(0\right)\left(\theta_k^d - \lambda_k\left(t\right)\right) + u_i^d\left(t\right) \tag{1}$$

In this expression, the first term, ξ_i^d, is a firm-specific demand component, which is observable to the firm before making its production and export decisions but unobservable to the researcher. The second term, $p_i^d\left(t\right)$, is the price paid by consumers in destination d for variety i in period t. The third term, $I_i^d\left(0\right)\left(\theta_k^d - \lambda_k\left(t\right)\right)$, is meant to capture the notion of 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 $\lambda_k\left(t\right)$ (until $\theta_k^d - \lambda_k\left(t\right)$ reaches zero). Because we do not restrict the values or the signs of these parameters in the estimation, the specification allows for the possibility of FMA but does not impose it. We will let the data tell us its presence and strength. Note that FMA does not appear in the theoretical models by Hoff (1997) and Hausmann and Rodrik (2003). One might conjecture that its presence should make missing export pioneers 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.

Note that other firms' prices do not appear in the demand function; their effects on demand are felt indirectly by affecting the aggregate demand shifter $\ln Y_k^d(t)$. This can be derived under a monopolistic competition assumption. (Note that in our sample, the potential number of exporters for any given 6-digit product is large, typically over 100. See Table A2 in Appendix 2.A later for additional details. We use this fact to justify the monopolistic competition assumption.)

The sales for variety i in destination d, in logarithm, take the form:

$$\ln s_i^d(t) = \xi_i^d - \alpha_k^d \ln p_i^d(t) + I_i^d(0)\left(\theta_k^d - \lambda_k(t)\right) + \ln Y_k^d(t) + u_i^d(t) \qquad (2)$$

Equation (2) will be identified by using data on actual sales by firms in different export destinations. The independent variables include price (unit export value), $p_i^d(t)$, 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 system of equations for multiple products (21 in the sample), and the system is non-linear, we need to impose some further structures on the parameters to make the computational burden manageable. We make the following assumptions: (1) $\alpha_k^d = \alpha^d + \alpha_k,\ \theta_k^d = \theta^d$. This says that the price elasticity parameter α varies by destination and product while the FMA parameter θ varies by destination but not by product. (2) $\lambda_k(t) = \lambda t$. This assumes that the FMA decays at a linear rate that is common across destinations or sectors. (3) $\ln Y_k^d(t) = \ln Y^d + \ln Y_k + \ln Y(t)$.These assumptions are made to reduce the number of parameters that needs to be estimated.

3.2 Variable Cost

The log marginal cost for firm i to produce and export to market d in period t is given below:

$$\ln c_i^d(t) = \gamma^d + \gamma_k + \gamma(t) + \kappa_{kw}\vec{w}_i(t) + \omega_i + v_i^d(t) \qquad (3)$$

γ^d is a fixed effect component that is common to all firms in a given destination, whereas γ_k is a fixed effect that varies only by product, and $\gamma(t)$ is a fixed effect that varies only by time period. Collectively, the marginal cost can vary by destination, product, and time period. However, such an assumption still rules out those components of costs that vary by location, product, and tariff, simultaneously, and in this sense, is restrictive. Allowing generic effects at the product-destination-time level would substantially increase the number of parameters, exacerbating computational burdens.

$\vec{w}_i(t)$ represents a set of observable components that affect a firm's marginal cost. An example of observable components would be the local wage (i.e., wage at the province-year level where a firm is located). We will also allow firm ownership and processing trade status to affect marginal cost of production and exporting.

The last two terms are meant to capture two different aspects of a firm's productivity. While ω_i is a permanent or time invariant component, $v_i^d(t)$ is a transitory or noise term. Both are unobservable to the researcher although ω_i is observed by the firm before making decisions on production and exports. $v_i^d(t)$ and $u_i^d(t)$ are noise shocks realized after the firm has made the decisions about production and exports. We assume that $u_i^d(t)$ and $v_i^d(t)$ follow an i.i.d. joint normal distribution with mean 0 and variance-covariance matrix Σ.

Under the assumption of monopolistic competition, a profit-maximizing firm facing the demand in equation (2) will charge a price of

$$\ln p_i^d(t) = \ln\left(\frac{\alpha_k^d}{\alpha_k^d - 1}\right) + \gamma^d + \gamma_k + \gamma(t) + \kappa_{kw}\vec{w}_i(t) + \omega_i + v_i^d(t) \qquad (4)$$

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

We will use unit export values as a proxy for prices charged by each firm. The pricing equation contains a set of destination, product, and period effects $\gamma^d + \gamma_k + \gamma(t)$, a firm-specific cost term $\vec{w}_i(t)$, and a productivity term ω_i. The markup term depends on price elasticity α_k^d which varies by destination and product. 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; in particular κ_{kw} is assumed to be the same across all products.

3.3 Firm's Decision Rules

We first consider a mature market that has already been explored by some exporting firms and therefore where a pioneer firm has already existed. A firm obtains a random draw on the fixed market entry cost (which can vary by destination, product, and time period), and decides if it wishes to export to that market. We then consider a market that has not yet been explored by any exporter from the same country. In that case, a firm has to decide if it wants to be the first exporter (i.e., a pioneer) in that market.

3.3.1 To Be an Exporter or Not?

Consider a market in which a pioneer already exists. For a representative firm i, the log expected profit before paying the entry cost is

$$\ln \pi_i^d(t) = \ln E_{u,v}\left[s_i^d(t)\left(p_i^d(t) - c_i^d(t)\right)\right]$$

where $E_{u,v}$ represents expectation taken over $u_i^d(t)$ and $v_i^d(t)$. Using the pricing and demand equations before, we obtain the firm's log profit as

$$\ln \pi_i^d(t) = \ln\left(\frac{1}{\alpha_k^d}\right) + \xi_i^d + I_i^d(0)\left(\theta_k^d - \lambda_k(t)\right) + \left(1-\alpha_k^d\right) E_{u,v} \ln p_i^d(t) + \ln Y_k^d(t) \tag{5}$$

where, substituting all equations into equation (5), and denoting $\mu_k^d = \frac{\alpha_k^d}{\alpha_k^d - 1}$, we have

$$\ln \pi_i^d(t) = \ln\left(\frac{1}{\alpha_k^d}\right) + \ln \bar{Y}_k^d(t) + \ln \bar{r}_i^d(t) + \ln b_i^d(t) \tag{6}$$

where

$$\ln \bar{Y}_k^d(t) = \ln Y_k^d(t) + \left(1-\alpha_k^d\right)\left(\ln \mu_k^d + \gamma^d + \gamma_k + \gamma(t)\right) + C_k^d$$

$$C_k^d = \ln E_{u,v}\left[\exp\left(u_i^d(t) + \left(1-\alpha_k^d\right) v_i^d(t)\right)\right]$$
$$\ln \bar{r}_i^d(t) = \xi_i^d + \left(1-\alpha_k^d\right)\left(\kappa_{kw}\vec{w}_i(t) + \omega_i\right)$$
$$\ln b_i^d(t) = I_i^d(0)\left(\theta_k^d - \lambda_k(t)\right) \tag{7}$$

In equation (6), 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 product line, 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 that captures an unobserved firm and destination-specific permanent demand shifter ξ_i^d, an unobserved firm-specific permanent productivity shifter ω_i, and observed set of firm characteristics $w_i(t)$. The last term, $\ln b_i^d(t)$, captures FMA.

For a given destination and a given time period, a firm draws an entry cost $\phi_i^d(t)$, which is independently and identically normally distributed. We assume the distributions of the entry cost in different sectors have the same standard deviation but different means. (This simplification is again to make the number of parameters more manageable for the nonlinear estimation). We use ψ to denote the set of parameters in this normal distribution[1].

The firm will choose to export to that particular market in that particular period if and only if the expected profit from doing so exceeds the entry cost:

$$\pi_i^d(t) > \phi_i^d(t)$$

Let us define the set of state variables as $\Omega_{it} = \left\{\xi_i, \omega_i, \vec{w}_i(t), \bar{Y}_k^d(t), b_i^d(t), \phi_i^d(t)\right\}$. Assuming that $\bar{Y}_k^d(t)$ is a random walk, we can define firm value as

$$V(\Omega_{i,t}) = \max_{I_i^d(t)\in\{0,1\}} \left\{\left[\pi_i^d(t) - \phi_i^d(t)\right] I_i^d(t) + \beta E\left[V(\Omega_{i,t+1})|\Omega_{i,t}\right]\right\}, \quad t \geq 1 \tag{8}$$

Equation (8) has two parts. The first part is the current profit of $\pi_i^d(t) - \phi_i^d(t)$ that the firm obtains by choosing to export today, $I_i^d(t) = 1$. The second part is the discounted future value where the discount factor is $\beta \in (0,1)$. The solution to the optimization 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.

3.3.2 To Be a Pioneer or Not?

Let us now consider a market not yet explored by a pioneer, and denote the time period as $t = 0$. We assume that all firms have the same cost of discovering any given market (in destination d for product k), which is denoted by F_k^d. The discovery cost needs to be paid on top of the fixed entry cost discussed previously. Importantly, the discovery cost needs to be paid only by the first exporter and not by follower firms, whereas the fixed entry cost needs to be paid by every exporter. Let us denote the distribution of a firm's state variables at $t = 0$ as $f_0(\Omega_{i,0})$. Hence f_0 is an aggregate state variable.

For future reference, we use χ to denote the probability that at least one firm will become a pioneer in the next period; naturally, χ depends on f_0. As long

[1] ψ has two components: mean and variance of this normal distribution.

as some firms are known to want to export in a future period, $\chi = 1$; otherwise $\chi = 0$.

Define a pioneer firm's value as $V^P(\Omega) = V\left(\Omega_{i,t}, I_i^d(0) = 1\right)$, and a follower firm's value as $V^F(\Omega) = V\left(\Omega_{i,t}, I_i^d(0) = 0\right)$. We use $I_i^d(0) = 1$ to represent that firm i chooses to be a pioneer, and zero otherwise. Hence the firm's optimization problem at $t = 0$ is

$$\bar{V}(\Omega_{i,0}, f_0) = \max_{I_i^d(0)} \left\{ \begin{array}{c} \left[\pi_i^d(0) - \phi_i^d(0) - F_k^d\right] I_i^d(0) + \beta I_i^d(0) EV^P(\Omega_{i,1}) \\ +\beta\left(1 - I_i^d(0)\right)\left[\chi(f_0) EV^F(\Omega_{i,1}) + (1 - \chi(f_0)) E\bar{V}(\Omega_{i,1}, f_1)\right] \end{array} \right\} \tag{9}$$

If the firm chooses to be a pioneer, its payoff is current profit net of the discovery cost plus a continuation value $\beta EV^P(\Omega_{i,1})$. If it chooses not to be a pioneer ($I_i^d(0) = 0$), its payoff is a convex combination of two possibilities: (1) if another firm becomes a pioneer next period ($\chi = 1$), firm i obtains the value of a follower firm, $\beta EV^F(\Omega_{i,1})$ (after discounting by one period); and (2) if no other firm becomes a pioneer ($\chi = 0$), its expected payoff is $\beta E\bar{V}(\Omega_{i,1}, f_1)$, since it will face the exact same choices next period as this period of whether to become a pioneer.

In equilibrium, every firm has a cutoff rule. For firm i, if and only if its entry cost is lower than its cutoff value, $\tilde{\phi}_i^d$, will it choose to export. Our timing assumption is that each firm first draws its export entry cost, which becomes observable by all firms. Hence given f_0, χ is determined. In particular, $\chi = 1$ if $\max_j\left(\tilde{\phi}_j^d - \phi_j^d(0)\right) > 0$ for at least some j, and $\chi = 0$ otherwise.

We can summarize the discussions on both the export decision and the pioneer decision. Using G to denote the cumulative density function (cdf) of a standard normal distribution, the probability that a firm would become a follower exporter (in a destination already explored, i.e., in period $t > 1$), p_e^d, can be expressed in the following way:

$$p_e^d\left(\Omega_i^d(t)\right) = \Pr\left[\phi \leq \bar{\phi}_i^d(t)\right] = G\left[\bar{\phi}_i^d(t)\right] \tag{10}$$

Similarly, the probability that a firm would become a pioneer in period $t = 0$, p_p^d, can be written as:

$$p_p^d\left(\Omega_i^d(0)\right) = \Pr\left[\phi \leq \tilde{\phi}_i^d\right] = G\left[\tilde{\phi}_i^d\right] \tag{11}$$

3.4 The Social Planner's Problem and Market Failures

We now consider a social planner, whose objective is to maximize the total value of all firms or the sum of firm values across products and destinations. The planner chooses whether to ask a firm to enter the market $I_i^{Pd}(t) \in \{0,1\}$ in each market and in each period. For a given product and destination, the planner's optimization problem is:

$$\max_{I_i^{Pd}(t)\in\{0,1\}} E_0 \sum_i \{\sum_{t=0}^{\infty} \{\beta^t \left[\pi_i^d(t) - \phi_i^d(t)\right] I_i^{Pd}(t)\} - I_i^{Pd}(0) F_k^d\} \tag{12}$$

subject to (5).

Inside the inner most big bracket is the discounted export profit for firm i. At a given time period t, if the firm is chosen by the planner to export ($I_i^{Pd}(t) = 1$), it earns a profit, $\pi_i^d(t)$, the same as in Equation (6), net of an entry cost, $\phi_i^d(t)$. The last term says that firm i must also pay the discovery cost, F_k^d, if it is chosen to be the pioneer exporter in period 0.

Since spillover only occurs at the time when pioneering activity takes place, it is the only time when the social planner's solution may differ from the decentralized equilibrium. Once a pioneer has been chosen (an event in period 0), the planner's decision rule (about whether any given firm should export or not) in subsequent periods would be exactly the same as what the firms would have chosen on their own in a decentralized market. Hence we can rewrite the planner's problem as:

$$\begin{aligned} J(f_0) \quad = \quad & \max_{I_i^{Pd}(t)} \sum_i \left\{ \left[\pi_i^d(0) - \phi_i^d(0) - F_k^d\right] I_i^{Pd}(0) + \beta \left(\sum_i I_i^{Pd}(t)\right) E\left[V^P(\Omega_{i,1})\right] \right\} \\ & + \beta\left(1 - \sum_i I_i^{Pd}(t)\right) J(f_1) \end{aligned} \tag{13}$$

subject to (9).

The first part of this problem is the sum of the firm values when a firm has been designated to be a pioneer by the planner. The second part is the sum of the firm values when no firm is chosen to be a pioneer in period 0. Let $x_i = \pi_i^d(0) - \phi_i^d(0)$, and $x = \sum_i \left[\pi_i^d(0) - \phi_i^d(0)\right]$. Recall our assumption that aggregate demand is a random walk (and log wage can be verified to be a random walk as well). Since profit is proportional to $\exp\left(\vec{w}_i(t) + \ln Y_k^d(t)\right)$, x is a Markov process too. Problem (13) can be simplified as

$$J(x) = \max\left\{x - F_k^d, \beta E_x J(x')\right\} \tag{14}$$

To see when market failure would emerge, it is instructive to compare when a central planner would want to designate a firm to be a pioneer based on (13) and when the firm would want to be a pioneer on its own in a decentralized equilibrium (9). Given the same initial distribution f_0, in a decentralized economy, firm i will choose to become a pioneer iff

$$x_i > F_k^d \tag{15}$$

In the planner problem, at least one firm will be designated as a pioneer iff

$$x - F_k^d > \beta E_x J(x') \tag{16}$$

That is, the planner would want a pioneer as long as the total gain of all firms minus the discovery cost, F_k^d, is greater than the value of waiting for a period. (The planner in general would choose no more than one pioneer, and if she wants a pioneer, would choose the most profitable firm to be the pioneer.) Because the planner and the firms are not solving the same optimization problem, there is a potential for market failure. We define "missing pioneers" as an event when condition (15) is not satisfied for any firm while condition (16) is satisfied. In other words, this type of market failure occurs when no individual firm wants to be a pioneer but the planner wants a pioneer.

We define the set of all potential exporters as E_0. The probability of "missing pioneers" could be formally defined as

$$\eta_k^d = \Pr\left[\begin{array}{c} \max_{i\in E_0} \phi_i^d(0) - \tilde{\phi}_i^d < 0, \\ x > F_k^d + \beta E_x J(x') \end{array}\right] \tag{17}$$

We now define a second type of market failure. In particular, there may be times when the social planner does not wish to have any pioneer this period (by asking all firms to wait for one period), yet at least one firm wants to be a pioneer in a decentralized economy. As an example, sometimes the highest productivity draw and the lowest entry cost draw are such that a firm finds it profitable enough to be a pioneer. Yet, knowing the distributions of the random shocks, the planner expects the productivity and entry cost draws to be even more favorable in the next period and therefore would want all firms to wait for a period. When this occurs, a pioneer firm could emerge prematurelly relative to the social optimum. (From the viewpoint of a would-be pioneer, it does not want to wait because in the next period, a different firm may become a pioneer and capture the FMA.) This problem of "premature or too many pioneers" is the opposite of the "missing pioneers" problem that Hausmann and Rodrik (2003) stress. The Type-II market failure occurs when

$$\varphi_k^d = \Pr\begin{bmatrix} \max_{i \in E_0} \phi_i^d(0) - \tilde{\phi}_i^d > 0, \\ x < F_k^d + \beta E_x J(x') \end{bmatrix} \tag{18}$$

We explain how we compute the probability of market failure in Appendix 1.B. We utilize the average number of firms that have ever exported in each HS6 product during 2000 to 2002 as a reference, which is shown in Appendix Table 3. We are going to vary E_0 to see the changes in η_k^d and φ_k^d.

4 Estimation Procedure and Data

4.1 Estimation Procedure

In the data, for each firm i, we observe a sequence of cost shifters $\vec{w}_i(t)$, and a sequence of participation choices $I_i^d(t)$. When a firm exports, we observe its unit export value, $p_i^d(t)$, and export sales $s_i^d(t)$. Let us denote the entire data set as D_f. Our empirical model consists of four structural equations: a demand equation (2), a pricing equation (4), an export decision rule (10) and a pioneer decision rule (11). The two decision rules are non-linear, adding substantial complexity to the estimation. Each equation contains an unobserved permanent component of productivity shock for a firm, ω_i, and unobserved demand shifter, ξ_i^d.

Our estimation strategy utilizes the framework of average likelihood function, following Arellano and Bonhomme (2011) and Roberts et al. (2012)[2]. Intuitively, we estimate ω_i and ξ_i^d using data on an individual firm's prices and quantities, conditional on a set of common parameters. Since the firm's export and pioneering decisions place restrictions on ω_i and ξ_i^d, we let the contributions of these unobserved variables to the likelihood function be weighted by a specified distribution. Details of the estimation procedure are explained in Appendix 1.

[2] We thank Daniel Xu for sharing his estimation codes with us.

4.2 Data and Identification of 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 for 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 70 parameters to estimate in our baseline model even after making a number of simplifying assumptions), it is wise for us to focus on a subset of sectors in this project.

In this paper, we work with the Chinese exporters of 21 electronics products spanning four 4-digit sectors (HS 8525-8528) in HS Chapter 85 (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 etc. Key features of these four sectors are reported in Appendix 2a.

We call a product-destination pair a market. Based on UN Comtrade data (available at the bilateral product level), we first identify a set of markets to which China did not export to during 1996-1999 but did during 2000-2002[3]. 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 sales and prices (unit values) evolve. In other words, we identify all the export pioneering activities (593 in total) during 2000-2002 and trace the dynamics of both the pioneers and all followers during 2000-2006.

A firm is called a pioneer if it is the very first Chinese exporter of a particular product to a particular destination. We call all subsequent entrants (for the same product-destination pair) as followers. While it is possible to have more than one pioneer firm for a given product-destination pair, it is extremely rare in practice. We find that in 97% of all the newly explored markets during 2000-2002, there is a single pioneer firm; in the remaining 3% of the cases, there are two pioneers. There is never a case with more than two pioneers. Therefore, for practical purposes, it is realistic to assume a single pioneer.

Importantly, when a product is not exported to a particular destination, some other products (out of our 21) are often still exported to this destination.

[3]By our procedure, we have bypassed a reclassification of HS codes from 1995 to 1996.

It is relatively uncommon to have a destination in which none of the 21 products is exported. This feature of the data is important in our ability to identify discovery cost parameters (the sum of a product component and a destination component) and other parameters.

In Appendix Table 3, we report the number of Chinese exporters for each of the 6-digit products in our sample. In over 75% of the cases (16/21), the number of exporters exceeds 100. The median and average numbers of exporters are 295 and 394, respectively. This means that these sectors are fairly competitive and the number of potential exporters is large. For any given destination and product, the number of exporters tends to be substantially lower (often between 3 and 10). This presumably is a result of firms' choices (e.g., in response to destination-specific entry costs).

5 Empirical Results

In this section, we apply the structural model to our sample. Recall that our model estimates price elasticity and FMA by destination, and the discovery costs are assumed to have both product and destination components. The more products and countries we include, the more parameters we are going to estimate (with the number of parameters growing multiplicatively). To further reduce computational time, we make two more assumptions. First, we assume all 6-digit products within a given 4-digit sector share the same parameters. Second, we cluster all countries into 7 destination regions according to their geographical and socioeconomic features: (i) US/Canada, (ii) Other countries in the Western Hemisphere, (iii) Former Soviet Republics (FSR), (iv) Rest of Europe, (v) Japan, Korea, Australia, New Zealand, (vi) Rest of Asia, and (vii) Africa. We 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 over 70 parameters to estimate.

These parameters are summarized as follows. In the demand equation, we have: (1) 7 destination-specific demand price elasticity parameters (α^d); (2) 3 sector specific demand price elasticity parameters (α_k) (We will set sector 8525 as the benchmark sector, such that the estimates for all other sectors are relative to Sector 8525); (3) 7 destination specific parameters for FMA, θ^d; (4) 1 linear decay rate (λ); and (5) 14 Aggregate demand dummies (sector/destination/time, 3+6+5=14). In the pricing equation, we have: (6) 7 destination-specific cost shifters (γ^d); (7) 3 product-specific cost shifters (γ_k); (8) 4 time-specific cost shifters $\gamma(t)$; (9) 5 other cost shifters, $w_i(t)$, including 3 firm ownership types (majority state owned, wholly foreign owned, foreign-Chinese jointly owned, with the benchmark being "the others" - mostly domestic privately owned firms), 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). We also have: (10) 9 parameters associated with the five random variables in the model. Finally, in the export and pioneer decision rules, (11) there are 10 discovery cost parameters (3 product and 7 destination specific parameters F_k^d).

5.1 Demand and FMA Estimates

Table 1 reports the estimates of the demand equation parameters (equation (2)). The first panel of Table 1 reports price elasticities α_k^d. For example, the price elasticity for sector HS8525 in the US/Canada region is -1.265, indicating that an increase in price by one percent is associated with a decline in export sales by 1.265%; the result is statistically significant. In the second part of the table, the paramters for initial FMA are positive for all regions and statistically significant for all but one regions (JPN/KOR/AUS/NZL). The initial FMAs range from 0.218 for Japan/Korea/Australia/New Zealand to 2.922 for US/Canada. A linear per-period decay rate λ is estimated to be -0.120; while it has the expected sign, it is not statistically significant.

5.2 Pricing Equation Estimates

Table 2 reports parameter estimates of the pricing equation (equation (4)). Our estimates suggest that firms involved in processing trade have a lower marginal cost, and firms located in higher-wage cities have a higher marginal cost. While the first parameter is statistically significantly different from zero at the 1% level, the second estimate is not statistically significant.

Interestingly, our estimates suggest that state-owned firms (SOEs), Sino-foreign joint ventures (JVs), and foreign wholly owned firms (FIEs) have marginal costs that are 0.70%, 1.47% and 0.67% higher than domestic private firms (the left-out group), respectively. It might be useful to comment on why foreign invested firms have a higher marginal cost than domestic private firms. Relative to domestic private firms, foreign-owned firms might choose to produce higher-quality varieties, which would require higher-cost inputs and therefore a

Parameter	Mean	Standard Deviation
Price elasticity-US/Canada	-1.265***	0.085
Price elasticity-Other western hemisphere	-1.171***	0.033
Price elasticity-Former Soviet Republics	-1.180***	0.036
Price elasticity-Rest of Europe	-1.104***	0.027
Price elasticity-JPN/KOR/AUS/NZL	-1.143***	0.056
Price elasticity-Rest of Asia	-1.157***	0.026
Price elasticity-Africa	-1.163***	0.029
Price elasticity-sector 8526	-0.045	0.034
Price elasticity-sector 8527	-0.036	0.043
Price elasticity-sector 8528	-0.369***	0.038
FMA-US/Canada	2.922***	1.039
FMA-Other western hemisphere	0.776***	0.303
FMA-Former Soviet Republics	1.456***	0.341
FMA-Rest of Europe	1.382***	0.302
FMA-JPN/KOR/AUS/NZL	0.218	0.446
FMA-Rest of Asia	0.872**	0.301
FMA-Africa	1.489	0.310
Linear decay rate	-0.120	0.076

Table 1: Parameters in Demand Equation

Notes: Aggregate demand coefficients for section, destination, and period are not reported. *** and ** denote statistically significant at the 1 % and 5 % levels, respectively.

higher marginal cost; but they may also be better managed which would imply a lower marginal cost. The net effect on the marginal cost depends on the relative strength of these two forces. Our estimates indicate that the higher quality effect dominates the better management effect.

5.3 Parameters for the Random Variables

There are five random variables in the model. First, a permanent firm-specific demand shock, ξ_i^d, in the demand equation, and a permanent firm-specific productivity draw, ω_i, in the marginal cost function are jointly log normally distributed. Second, a transitory demand shock, $u_i^d(t)$, in the demand equation, and a transitory productivity shock, $v_i^d(t)$, in the marginal cost function are also jointly log normally distributed. Finally, for every firm in every market in every period, there is a random fixed entry cost, $\phi_i^d(t)$, that is independently and normally distributed. As specified, not all moment parameters can be identified. Following Roberts et al. (2012), we impose a value of one for the standard de-

Parameter	Mean	Standard Deviation
SOE cost add-up	0.702***	0.032
JV cost add-up	1.471***	0.044
FIE cost add-up	0.670***	0.041
Local wage	0.091	0.070
Processing status	-0.142***	0.031

Table 2: Parameters in Pricing Equation

Notes: 14 coefficients for destination, period, and sector fixed effects are not reported to save space; *** denotes statistically significant at the 1 % level.

viation of the export entry cost, $\phi_i^d(t)$, but leave its mean to be a parameter to be estimated. While we allow for non-zero correlations between the permanent components of the demand and productivity shocks, and between the transitory components of the demand and productivity shocks, we assume independence between the permanent and the transitory shocks.

There are in total nine parameters. We report the estimation results in Table 3. We note that the standard deviation for the permanent demand shock is more than 10% greater than that for the permanent productivity shock. This pattern is consistent with the findings reported in Roberts et al. (2012) for Taiwanese footwear exporters. A relatively big dispersion of the persistent demand shock across firms may reflect dispersion in product quality across firms or dispersion in consumer taste over varieties.

The average fixed entry cost is estimated to be 11% of the mean one-period firm profit. Since we can back out firms' sales and costs in monetary terms, we infer that the average fixed entry cost into an export market per period is RMB 51,116 (or about US$ 8,244).

5.4 Discovery Cost Parameters

Estimates of the discovery costs in each sector and destination region are presented in Table 4. The discovery costs are expressed in multiples of the average firm value. (The average firm values differ by sector and region.) To infer firm value from one-period firm profit, we need an assumption on the discount factor. Assuming a discount factor of $\beta = 0.9$, we can infer that the average firm value across all sectors and regions is about 446,220 RMB, and correspondingly, the discovery cost on average is about 156,180 RMB (about US$ 25,200, or 35% of the average firm value) from Table 4. Note, while the exact monetary values

Permanent Shocks		
	Mean	Standard Deviation
Productivity	-0.035	1.893***
	(0.028)	(0.018)
Demand	-0.039**	2.139***
	(0.017)	(0.023)
corr	0.554***	
	(0.014)	
Transitory Shocks		
u		1.753***
		(0.137)
v		0.737***
		(0.155)
corr		0.121
		(0.134)
Export Cost/Profit		
ϕ	0.11	1
	(0.10)	

Table 3: Parameters for the Random Variables

Notes: *** and ** denote statistically significant at the 1 % and 5 % levels, respectively. Standard errors are reported in brackets.

of the discovery costs require an assumption on the discount factor, subsequent assessments of market failures do not depend on the exact monetary values of the discovery costs and therefore are independent of this assumption.

Because the discovery costs are assumed to be paid by a pioneer firm in a given market but not by follower firms, our finding of positive discovery costs also implies evidence of informational spillover from pioneer firm to all follower firms. In this sense, we confirm the findings in Freund and Pierola (2010) and Artopoulos, Friel, and Hallak (2011) that positive spillover exists.

6 Market Failures in a Decentralized Economy

As we have stated earlier, the missing pioneer problem occurs if and only if two inequalities are 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 discovery cost to discover that new market. Second, the discovery cost has to be greater than the expected profit of any individual firm. Otherwise,

	HS8525		HS8526	
	Mean	**Std**	**Mean**	**Std**
US, Canada	0.36***	0.10	0.65***	0.04
Other western hemisphere	0.42***	0.14	0.56***	0.10
Former Soviet Republics	0.49***	0.09	0.56***	0.08
Other European countries	0.26	0.32	0.40**	0.20
JPN/KOR/AUS/NZL	0.46***	0.09	0.33***	0.16
Rest of Asia	0.36*	0.19	0.66***	0.10
Africa	0.55***	0.09	0.68***	0.07
	HS8527		HS8528	
	Mean	**Std**	**Mean**	**Std**
US, Canada	0.05	0.05	0.41***	0.09
Other western hemisphere	0.63***	0.08	0.51***	0.11
Former Soviet Republics	0.59***	0.08	0.42***	0.12
Other European countries	0.62***	0.07	0.31	0.26
JPN/KOR/AUS/NZL	0.58***	0.06	0.45***	0.09
Rest of Asia	0.63***	0.08	0.46***	0.13
Africa	0.74***	0.06	0.59***	0.10

Table 4: Discovery Costs in Multiples of Average Firm Value

Notes: Std=standard deviation. ***, ** and * denote statistically significant at the 1 %, 5 % and 10 % levels, respectively.

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.

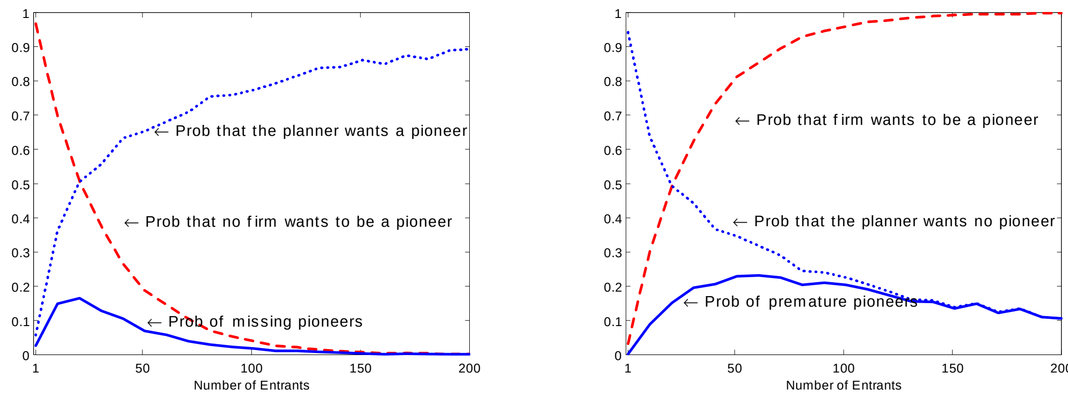
We have also discussed a second type of market failure - the problem of premature pioneering activities - which is markedly different from the Hausmann-Rodrik hypothesis.

6.1 Probabilities of Market Failures

We now reflect on the probability of market failure as a function of the potential number of entrants. Even without doing any structural estimation, we may conjecture that the relationship between the probability of "missing pioneers" and the number of potential exporters should resemble an inverse V. 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 be the pioneer anyway even if there is knowledge spillover to other firms. Therefore, the probability of "missing pioneers" is likely to have an inverse-V shape. This is the limit of our intuition. How fast does the probability of "missing pioneers" increase when the number of firms increases? Where does the probability peak? How fast would the probability decline after it peaks? We will have to use structural parameters and simulations to answer these questions.

Fixing a particular value for the number of potential exporters in E_0, we compute probability of market failure η_k^d by randomly drawing firms, and plotting it in Figure 1. (This refers to the fraction of all product-destination combinations for which both inequalities hold simultaneously.) We present the probability of "missing pioneers" (Type-I Market Failure) in the left graph, and the probability of "premature pioneers" (Type-II Market Failure) in the right graph. In the left graph, we plot three lines: the probability that no firm would want to become a pioneer in a decentralized market ($\max_{i \in E_0} \pi_i^d(0) - \phi_i^d + \beta E_\phi V(\Omega_{i,1}, 1) - \beta E_\phi V(\Omega_{i,1}, 0) < F_k^d$), the probability that the social planner prefers to have a pioneer, ($x > F_k^d + \beta E_x J(x')$), and the probability that both are true. We vary the number of entrants from 1 to 200 firms. (Recall the mean and median numbers of exporters across the 21 products in the data are 394 and 295, respectively.) As we can see, the probability that no single firm would want to become a pioneer firms starts at a relatively high number (over 97%), and decreases relatively fast as the number of potential entrants 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 very low, and increases as the number of entrants increases. Logically, the probability of "missing pioneers" - the probability that both conditions satisfied - should be lower than the smaller of the two. Because "no firm wants to be a pioneer" and "the planner wants a pioneer" are not independent events, the probability of "missing pioneers" turns out to be lower than the lower envelope of the other two curves.

In the right graph, the probability that some firms want to be a pioneer rises with the number of potential exporters, while the probability that the planner does not want a pioneer (in a given period) declines in the number of potential exporters. The probability of Type-II market failure also has an inverse-V shape. Relative to the probability of "missing pioneers," however, the probability of "premature pioneers" reaches a higher peak, and declines less fast



The case of missing pioneers

The case of premature pioneers

Figure 1: Probability of market failures

with the number of potential exporters.

To summarize, our structural estimation produces interesting results. In particular, we find that "missing pioneers" - emphasized by Hausmann and Rodrik (2003) and the existing literature on market failure in export activities - are a low probability event. If the number of potential exporters is equal to the mean (394) or the median (295) in the data, the probability of "missing pioneers" is essentially zero. Even if we search for the number of potential exporters that would maximize the probability of "missing pioneers," the peak probability is still less than 20%. On the other hand, "premature pioneers" are somewhat more likely than "missing pioneers." This seems to turn the conventional wisdom in this literature on its head.

6.2 When are missing pioneers more likely to occur?

The finding that "missing pioneers" are a low probability event is not a predetermined outcome by our specification. To see this, we now try to explore how the dispersions of productivity and demand shocks (relative to the magnitude of the discovery costs) affect the likelihood of market failure. Our intuition is that when the dispersions are small, the probability of missing pioneer can become very large. For instance, we can think of an extreme case when there is no dispersion and all firms are identical. (This extreme case happens to be the assumption used in the model of Hausmann and Rodrik, 2003). Imagine there are 100 identical potential exporters in a market. The expected profit from exporting for each firm is \$100 but the cost of discovery is \$500. In this case, no individual firm wants to be a pioneer because its expected profit is lower than the discovery cost. Yet, clearly, the social planner wants to designate a firm to be a pioneer because the total expected profit across all firms is \$1 million, far exceeding the discovery cost. We can verify this intuition in our model too. Specifically, we will vary the size of the dispersions of the permanent demand and productivity shocks while keeping all other parameters fixed. Of course, we can also vary the size of the discovery cost while keeping the dispersions constant.

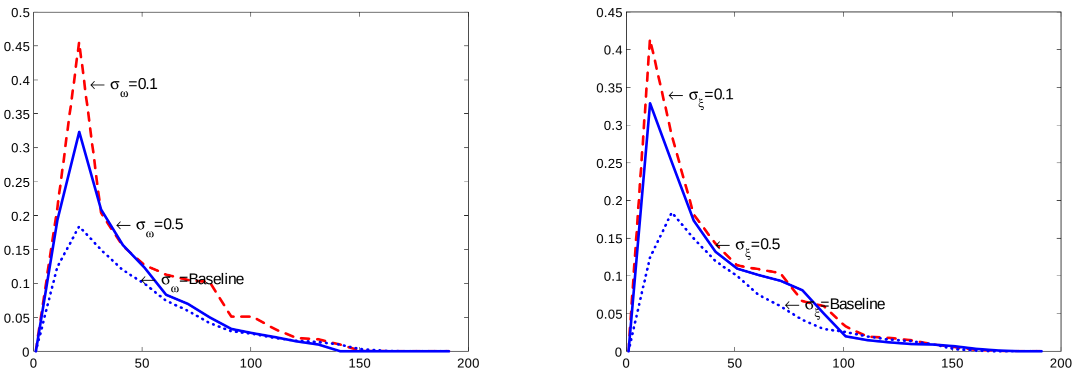
In the left graph of 2, we plot the probability of "missing pioneers" corresponding to three different values of permanent productivity dispersion across firms (σ = baseline estimate of 1.893, 0.5, and 0.1, respectively), while keeping all other parameters at the values of their baseline estimates. Clearly, as the productivity dispersion becomes smaller, "missing pioneers" become more likely.

In the right graph of 2, we progressively reduce the size of permanent demand dispersion across firms (σ = baseline estimate of 2.139, 0.5, and 0.1, respectively), while keeping all other parameters at the values of their baseline estimates. Clearly, as the demand dispersion becomes smaller, "missing pioneers" also become more likely.

In the left graph of 3, we progressively increase the discovery cost (discovery cost = baseline estimate, 1.5 x baseline, and 2 x baseline, respectively), while keeping all other parameters at the values of their baseline estimates. Clearly, as the discovery cost becomes greater (and therefore positive spillover becomes more severe), "missing pioneers" become more likely.

Finally, in the right graph of 3, we simultaneously lower the dispersions of the productivity and demand draws across firms and raise the discovery cost. We can see clearly that the probability of "missing pioneers" increases even more. In fact, when the dispersions for both productivity and demand draws are 0.1, and the average discovery cost is twice the baseline estimate, the probability of "missing pioneers" can reach nearly 100% very quickly and stay very high even as the number of potential exporters increases to 200.

We conclude from this exercise that a low probability of missing pioneers is not an artificial outcome of our specification. In the data, productivity and demand shocks are sufficiently dispersed across firms (relative to the size of the



Varying productivity dispersion

Varying demand dispersion

Figure 2: Varying dispersions

discovery costs) so that it is not likely for the "missing pioneers" problem to arise. To put it differently, the homogenous firm assumption in the model of Hoff (1997) and Hausmann and Rodrik (2003) turns out to be a key for their conclusion of market failure.

7 Extensions and Robustness Checks

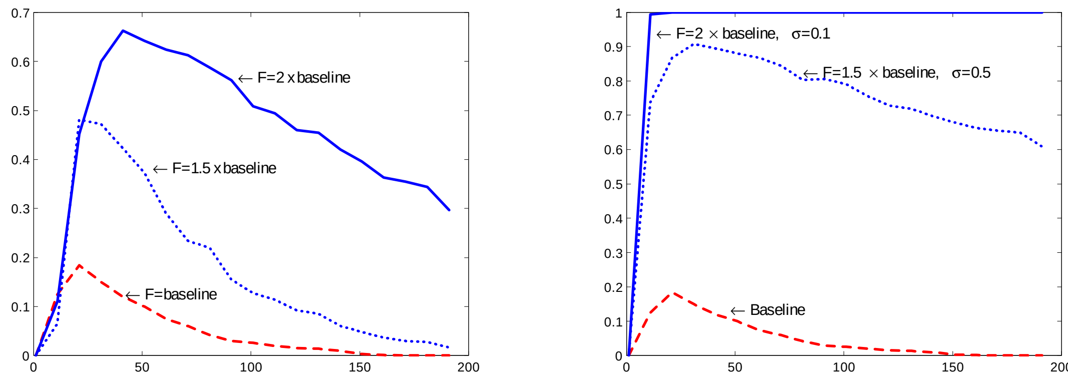
We now explore a number of robustness checks and extensions.

7.1 Dynamic Setup

We extend our benchmark model into a dynamic environment. In the demand equation, we introduce a consumer loyalty effect. In particular, if a firm has exported to a particular market in a previous period, then the demand for its variety is potentially higher in this period:

$$\ln s_i^d(t) = \xi_i^d - \alpha_k^d \ln p_i^d(t) + \rho I_i^d(t-1) + I_i^d(0)\left(\theta_k^d - \lambda_k(t)\right) + \ln Y_k^d(t) + u_i^d(t) \tag{19}$$

In (19), $I_i^d(t-1)$ is an indicator function. It is 1 if the firm exported last period, and 0 otherwise. Hence a positive value of ρ captures the idea of consumer loyalty. Note that we do not impose consumer loyalty but merely allow it in our



Varying discovery cost

Varying dispersion and discovery cost

Figure 3: Varying discovery cost

specification. The notion of "consumer loyalty" differs from FMA. While FMA can only be enjoyed by the pioneer firm, consumer loyalty applies to follower firms too.

Once we allow consumer loyalty, the firm's decision problem in (8) becomes dynamic. In other words, the export decision in one period will affect the profitability of exporting in the subsequent period. This adds substantial complexity to our estimation. To save space, we explain our estimation procedure in Online Appendix 3.A, and do not tabulate the results. We only note that the coefficient on consumer loyalty is 0.79 and statistically significant (and all other parameter estimates are similar to the baseline case). Hence we find empirical support for the notion of consumer loyalty. While the estimation is more involved, it turns out the inference on the probabilities of the two types of market failures are qualitatively similar to the benchmark model. Quantitatively, the probability of "missing pioneers" is even lower. This is perhaps intuitive: the possibility of consumer loyalty should induce firms to be more willing to export and to do so sooner rather than later.

7.2 Shutting Down FMA

To see the importance of FMA in our inference, we shut down the FMA in this section. In the benchmark case, we assume a pioneer firm receives a boost in its export sales at the beginning and then gradually decays to 0. Now we assume in the demand equation (2), $\theta = \lambda = 0$. Hence pioneer firms do not have any advantage at the beginning. Without FMA, firms could become more reluctant to be a pioneer.

We report the results in Online Appendix 3.B. It turns out that the probability of "missing pioneers" is stil low in this case, with the peak probability being below 20% (when the number of potential exporters is around 40). The probability of "premature pioneers" is also low.

7.3 Possible Biases from Using Chinese Data

We reflect on possible biases introduced by the use of Chinese data. Since exchange rate undervaluation could promote entries into new export markets (Freund and Pierola, 2012), 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, both narrative reporting before 2003 and 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 4, we plot the forward Chinese exchange rate (units of Chinese yuan 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 would depreciate in the subsequent 3 or 12 months. From late 2003 to 2011, the forward spot difference 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 overvalued and a depreciation rather than an appreciation would have to come soon. Frankel and Wei (2007) also suggest that the RMB was not undervalued before 2003, and postulate that the switch in market assessment of the Chinese exchange rate was started 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 were

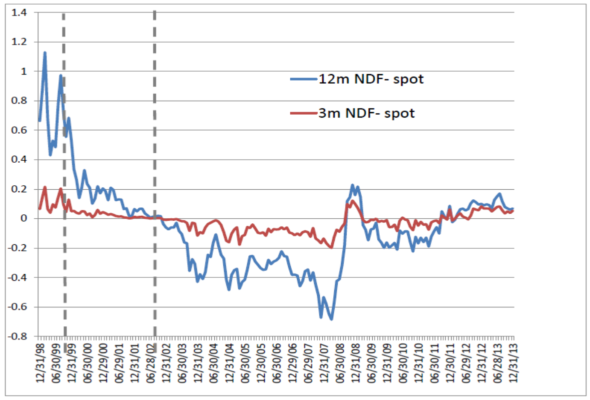


Figure 4: RMB/dollar Forward Rate (1998-2013)

no active government actions adjusting the nominal exchange rate during these 11.5 years. If there were exchange rate manipulation, it was done by neglecting to adjust the nominal exchange rate. Since prices and wages can adjust upward (though maybe more difficult to adjust downwards), it is hard to keep the real exchange rate undervalued anyway. 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 overvalued during 2000-2002, which should bias against finding a low probability of missing pioneers.

The standard measure of real effective exchange rate suffers from the problem of ignoring trade in intermediate goods and global value chains. Once one makes the correction (Patel, Wang, and Wei, 2014), the Chinese real exchange rate both on a multilateral basis and relative to the US dollar exhibited a steady and strong appreciation since 2000.

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

(CVD) 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") subject to an antidumping law suit (which was lodged by the United States in 2003). In that case, the US International Trade Commission eventually imposed an antidumping duty of 78.45% to Chinese TV exporters[4]. As a robustness check, we exclude this sector from our data and re-estimate the model. However, we still find a low probability of missing pioneers.

The third concern is that China might have superior export performances than other countries in sector HS8525 to 8528, resulting in less observed market

[4] See http://www.usitc.gov/trade_remedy/731_ad_701_cvd/investigations/2004/color_television_receivers_from_china/final/PDF/fr_commerce_order.pdf for details.

failure. By superior export performance, we mean the export growth from extensive margin (export to new product-country pairs) might be much greater than that from intensive margin (export to existing product-country pairs) in China than in other similar countries. If this is true, the use of Chinese data could produce an atypically low and unrepresentative probability of market failure. To check whether such problem exists, we decompose export growth of China and comparators (Brazil, India, Japan, Poland, Czech Republic, and Italy) from 2000 to 2002 into extensive and extensive margins. The results are reported in Appendix 3.C. As it turns out, China didn't stand out in terms of extensive margin growth when compared to these countries.

7.4 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 computational 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 larger or richer economies (e.g., due to higher costs of advertisement or hiring of a consultant), implying a higher probability of "missing pioneers". On the other hand, costs of dealing with corruption and regulatory barriers could be lower in more developed economies, implying a lower probability of "missing pioneers". 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 region, would add many more parameters. This would increase the computational time substantially. Instead, we take a short cut and 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 Appendix 3D. We find that probability of "missing pioneers" is still low in an absolute sense. Comparing these results with the baseline case, it appears that the probability of "missing pioneers" tends to be a bit lower and the probability of "premature entrants" tends to be higher when we restrict our attention to richer and larger markets.

7.5 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 of 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 to an expanded set of observable firm characteristics in equation 4. The first is a firm's own export value of different products to the same destination in period t-1, which captures learning about the destination from one's own past exports. Albornoz et al. (2010) have explored this idea in a reduced-form estimation. The second is a firm's own export value of the same products to different destinations in period t-1, which captures learning about the product from one's own past exports regardless of destinations.

Besides learning from a firm's own experience, we also explore possible learning from other firms' experience. Fernandes and Tang (2012) study the spillover effects of other exporters on new exporters. Therefore, our third new channel is learning about a given destination through other firms' total exports of different products to the same destination in period t-1[5]. The fourth channel is learning about the product through other firms' export value of the same product to different destinations in period t-1.

If any of the learning channels is operational, we expect it to result in a reduction in the marginal cost. Moreover, we expect that learning from one's own experience is (at least weakly) more powerful than learning from other firms' experience. However, we do not impose these restrictions in the estimation. The set of state variables Ω_i^d now includes these four additional variables[6]. Note that,

[5] Fernandes and Tang (2012) also examine whether learning dissipates with physical distance but find no evidence in favor of this hypothesis. For this reason, we do not incorporate this feature. Incorporating such a feature in our non-linear system would have substantially complicated the estimation.

[6] We keep equation (2) the same and change equation (4) by augmenting $\vec{w}_i(t)$. Hence $\vec{w}_i(t)$ includes not only the firm's ownership, processing trade status, and local wage, but also four new variables that captures learning from own experience and learning from other firms.

by changing the marginal cost, these modifications also change the probability of export in equation (10). Therefore, these additional learning channels could also change the pioneering decisions and therefore the probabilities of "missing pioneers" and "premature pioneers."

Using the expanded set of structural parameters, we re-compute the probabilities of Type-I and Type-II market failures, respectively. The results are presented in Appendix Figure 5 in Appendix 3.D. Compared to the baseline case, we find that the probability of "missing pioneers" has now dramatically declined, with the peak probability not even reaching 2%. In contrast, the probability of "premature pioneers" has generally increased, with the peak probability reaching close to 45%. These changes in the probabilities of market failures are consistent with the intuition that, by reducing the marginal cost (and increasing the expected profit from exporting), the additional learning channels make it more likely for firms to want to be a pioneer.

7.6 Intermediary Firms

Intermediary firms are firms that specialize in exports and imports but may not be producers themselves. They play an important part in facilitating trade (see Ahn, Khandelwal, and Wei, 2011, for a model of intermediary firms and evidence from China). 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 HS 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 them.

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 probabilities of Type-I and Type-II market failures and report the results in Online Appendix 3.E. (In this estimation, we allow for "consumer loyalty" as in Section 7.1; dropping "consumer loyalty" does not qualitatively change the conclusion.)

Here is the key finding: without giving credit to intermediary firms in conquering new markets, the probability of market failure tends to be moderately

Then equations (10) and (11) are also changed since state variables in Ω_i^d are augmented too.

higher than the corresponding case presented in Section 7.1 (but lower than the baseline case without the "consumer loyalty" effect but with intermediary firms). To summarize, our key conclusion of a low probability of the "missing pioneers" problem does not appear to be materially affected by the presence or absence of intermediary firms.

7.7 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 with identical policy barriers on imports from non-member countries (and sometimes with free mobility of capital and labor among member countries). There are five common markets in our sample: the European Community (EC), the Caribbean Common Market (CARICOM), the Central American Common Market (CACM), MERCOSUR, and the Common Market for Eastern and Southern Africa (COMESA) [7]. One could make a case for assuming that only one discovery cost needs to be paid to enter a given common market. Once an exporter reaches one member country, it can 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. With the correspondingly new definition of a market, 444 new markets were explored during 2000-2002. We re-estimate the structural model, re-compute the probabilities of Type-I and Type-II market failures, and report the results in Appendix 3.F. Compared to the baseline case, we find that this extension results in a lower probability of "missing pioneers" but a higher probability of "premature pioneers." Our interpretation is that, by allowing a single discovery cost for entering all countries within a common market, this change in assumption raises the expected profit from the pioneering activities and therefore makes it more attractive for firms to become pioneers.

7.8 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 discovery involves firms exporting brand new products to the world market. We now make an attempt at gauging the likelihood of "missing pioneers"

[7] Memberships in these common markets are spelled out in Online Appendix 3.F.

in this type of activity 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.

To define a set of countries similar to China during 2000-2002, we look at all countries whose per capita income is within (-20%, +50%) of the Chinese level ($1135 in 2002). 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 ($$1286), Syria ($1270), Honduras ($1197), Paraguay ($1135), Swaziland ($1131), Philippines ($1005), Nicaragua ($995), Turkmenistan ($970), Guyana ($962), Congo ($920), and Indonesia ($910).

For each country on this list, we consider each of their HS 6-digit manufacturing export products as a potential comparative advantage product for China. Note that 6-digit HS code is the most disaggregated level of 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. (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.) Let us call this set A. They are part of the "potential comparative advantage products" for China.

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 a similar level of income could conceivably export. R+M=4225.

Some of the products in M may be ones for which China has no genuine comparative advantage. For example, some "similar countries" may export processed gold products because they happen to have an abundant gold reserve but gold is scarce in China. But to err on the side of capturing the upper bound of "missing pioneers," we regard all goods in M as reflecting Type-I market failure. In this case, the probability of Type-I 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: HS 854219 "Monolithic digital integrated circuits", HS 710812 "Gold in other unwrought forms", HS 482359 "Other paper and paperboard", HS 481012 "Paper and paperboard", HS 710813 "Gold in other semi-manufactured forms", HS 410410 "Whole bovine skin leather", HS 440320 "Other coniferous tropical woods", HS 854214 "other monolithic digital integrated circuits", HS 560730 "Other hard fibres", and HS 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 three of these products (HS 481012, 560730, and 854214) are exported by three or fewer countries only; they might not represent genuine potential comparative advantage products for China.

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

8 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 first mover advantage 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 "missing pioneers" is generally not very high in spite of its theoretical plausibility. Furthermore, we point out a seond type of market failure, that of "premature pioneers," and show evidence that "premature pioneers" are at least as likely as "missing pioneers." These conclusions appear robust in a number of extensions and checks we have examined.

There are two categories of contributions from the paper: (a) a new framework to assess two types of market failure in export pioneering activities, and (b) an application to the Chinese data. The framework can in principle be applied to firm-product-destination-time data from other countries. Such applications could allow one to eventually develop insight about how country characteristics may affect probabilities of market failure. We leave such exercises to future research.

References

AHN, J., A. K. KHANDELWAL, AND S.-J. WEI (2011): "The role of intermediaries in facilitating trade," *Journal of International Economics*, 84(1), 73–85.

ALBORNOZ, F., H. F. CALVO PARDO, G. CORCOS, AND E. ORNELAS (2012): "Sequential exporting," *Journal of International Economics*, 88(1), 17–31.

AMITI, M., AND C. FREUND (2010): "The anatomy of China's export growth," in *China's growing role in world trade*, pp. 35–56. University of Chicago Press.

AMSDEN, A. H. (1992): *Asia's next giant: South Korea and late industrialization*. Oxford University Press.

ARELLANO, M., AND S. BONHOMME (2009): "Robust priors in nonlinear panel data models," *Econometrica*, 77(2), 489–536.

ARELLANO, M., AND S. BONHOMME (2011): "Nonlinear Panel Data Analysis," *Annual Review of Economics*, 3(1), 395–424.

ARROW, K. J. (1962): "The economic implications of learning by doing," *The review of economic studies*, 29(3), 155–173.

Artopoulos, A., D. Friel, and J. C. Hallak (2011): "Lifting the Domestic Veil: The Challenges of Exporting Differentiated Goods Across the Development Divide," Discussion paper, National Bureau of Economic Research.

——— (2013): "Export emergence of differentiated goods from developing countries: Export pioneers and business practices in argentina," *Journal of Development Economics*, 105, 19–35.

Aw, B. Y., M. J. Roberts, and D. Y. Xu (2008): "RD investments, exporting, and the evolution of firm productivity," *The American Economic Review*, 98(2), 451–456.

Berry, S. T. (1994): "Estimating Discrete-Choice Models of Product Differentiation," *RAND Journal of Economics*, 25(2), 242–262.

Bolton, P., and C. Harris (1999): "Strategic experimentation," *Econometrica*, 67(2), 349–374.

Bown, C. P., and R. McCulloch (2005): "US trade policy toward China: Discrimination and its implications," *Working Paper*.

Casella, A., and J. E. Rauch (2003): "Overcoming Informational Barriers to International Resource Allocation: Prices and Ties," *The Economic Journal*, 113(484), 21–42.

Das, S., M. J. Roberts, and J. R. Tybout (2007): "Market entry costs, producer heterogeneity, and export dynamics," *Econometrica*, 75(3), 837–873.

Eaton, J., M. Eslava, M. Kugler, and J. Tybout (2008): "Export dynamics in colombia: Transactions level evidence," *Banco de la Republica de Colombia, Borradores de Economia*, 522.

Ferguson, S., and R. Forslid (2013): "Sizing Up the Uneven Impact of Embassies on Exports," *working paper, Research Institute of Industrial Economics and Stockholm University.*

Fernandes, A., and H. Tang (2012): "Learning from Neighbors' Export Activities: Evidence from Exporters' Survival," Discussion Papers Series, Department of Economics, Tufts University 0766, Department of Economics, Tufts University.

——— (2014): "Learning to Export from Neighbors," *CESifo Working Paper*.

Frankel, J. A., and S.-J. Wei (2007): "Assessing China's exchange rate regime," *Economic Policy*, 22(51), 575–627.

Freund, C., and M. Pierola (2010): "Export entrepreneurs: evidence from Peru," *World Bank Policy Research Working Paper Series*.

Freund, C., and M. D. Pierola (2012): "Export surges," *Journal of Development Economics*, 97(2), 387–395.

Griliches, Z. (1957): "Hybrid corn: An exploration in the economics of technological change," *Econometrica*, pp. 501–522.

Grossman, G. M., and E. Rossi-Hansberg (2010): "External economies and international trade redux," *The Quarterly Journal of Economics*, 125(2), 829–858.

Hausmann, R., and D. Rodrik (2003): "Economic development as self-discovery," *Journal of development Economics*, 72(2), 603–633.

Hoff, K. (1997): "Bayesian learning in an infant industry model," *Journal of International Economics*, 43(3-4), 409–436.

Iacovone, L., and B. S. Javorcik (2010): "Multi-Product Exporters: Product Churning, Uncertainty and Export Discoveries," *The Economic Journal*, 120(544), 481–499.

Kehoe, T. J., and K. J. Ruhl (2013): "How Important is the New Goods Margin in International Trade?," *Journal of Political Economy*, 121(2), 358–392.

Klinger, B., and D. Lederman (2004): "Discovery and development: an empirical exploration of new products," *World Bank Policy Research Working Paper*, (3450).

Lederman, D., M. Olarreaga, and L. Payton (2009): "Export Promotion Agencies Revisited," *World Bank Policy Research Working Paper Series*.

Lieberman, M. B., and D. B. Montgomery (1998): *First-mover (dis) advantages: Retrospective and link with the resource-based view*. Graduate School of Business, Stanford University.

Lucas Jr, R. E. (1993): "Making a miracle," *Econometrica*, pp. 251–272.

Macchiavello, R. (2010): "Development uncorked: reputation acquisition in the new market for Chilean wines in the UK," *Working Paper, Centre for Economic Policy Research.*

Melitz, M. J. (2003): "The impact of trade on intra industry reallocations and aggregate industry productivity," *Econometrica*, 71(6), 1695–1725.

Nitsch, V. (2007): "State visits and international trade," *The World Economy*, 30(12), 1797–1816.

Rauch, J. E. (1996): "Trade and search: Social capital, sogo shosha, and spillovers," Discussion paper, National bureau of economic research.

——— (1999): "Networks versus markets in international trade," *Journal of international Economics*, 48(1), 7–35.

——— (2001): "Business and social networks in international trade," *Journal of economic literature*, 39(4), 1177–1203.

Rauch, J. E., and V. Trindade (2002): "Ethnic Chinese networks in international trade," *Review of Economics and Statistics*, 84(1), 116–130.

Roberts, M. J., D. Y. Xu, X. Fan, and S. Zhang (2012): "A structural model of demand, cost, and export market selection for chinese footwear producers," Discussion paper, National Bureau of Economic Research.

Rodrik, D. (2004): "Industrial policy for the twenty-first century," *KSG Working Paper No. RWP04-047.*

Rose, A. K. (2007): "The foreign service and foreign trade: embassies as export promotion," *The World Economy*, 30(1), 22–38.

Wagner, J. (2012): "International trade and firm performance: a survey of empirical studies since 2006," *Review of World Economics*, 148(2), 235–267.

Wagner, R., and A. Zahler (2011): "New exports from emerging markets: do followers benefit from pioneers?," *Working Paper.*

1 Appendix: Estimation Procedure

In the data, for each firm i, we observe a sequence of cost shifters $w_i(t)$, and a sequence of participation choices $I_i^d(t)$. When a firm exports, we observe its unit export value, $p_i^d(t)$, and export sales $s_i^d(t)$. Let us denote the entire data set as D_f. Our empirical model consists of four structural equations: a demand equation (2), a pricing equation (4), an export decision rule (10) and a pioneer decision rule (11). The two decision rules are non-linear, adding substantial complexity to the estimation. Each equation contains an unobserved permanent component of productivity shock for a firm, ω_i, and unobserved demand shifter, ξ_i^d. Our estimation strategy utilizes the framework of average likelihood function, following Arellano and Bonhomme (2011) and Roberts et al. (2012)[1]. Intuitively, we estimate ω_i and ξ_i^d using data on an individual firm's prices and quantities, conditional on a set of common parameters. Since the firm's export and pioneering decisions place restrictions on ω_i and ξ_i^d, we let the contributions of 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 $\Theta = \left\{\alpha^d, \alpha_k, Y_k^d(t), \lambda, \theta^d, \gamma^d, \gamma_k, \gamma(t), \gamma_{kw}, \Sigma, \psi, F_k^d\right\}$. All parameters in Θ are to be estimated structurally. 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

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

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

$$\begin{aligned} l(D_f|\Theta, \xi, \omega) \quad = \quad & \prod_{d,t} g\left[\ln\left(s_i^d(t)\right), \ln p_i^d(t); \Sigma\right]^{I_i^d(t)} G\left[\bar{\phi}_i^d(t); \Theta\right]^{I_i^d(t)} \left[1 - G\left(\bar{\phi}_i^d(t); \Theta\right)\right]^{1-I_i^d(t)} \\ & G\left(\tilde{\phi}_i^d; \Theta\right)^{I_i^d(0)} \left[1 - G\left(\tilde{\phi}_i^d; \Theta\right)\right]^{1-I_i^d(0)} \end{aligned}$$

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 parts. The first is the contribution of the firms' export sales and prices, and the second is the

[1] We thank Daniel Xu for sharing his estimation codes with us.

contribution from the firms' decisions on pioneer and export status. 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 and then use MCMC to update our guesses on ξ and ω.

The firm-specific demand and cost components are sampled firm by firm and we can estimate their joint distribution. Assuming (ξ, ω) follow a joint normal distribution with the vector of parameters W[2], we Bayesian-update W in each iteration from the previous sampling step. We explain the estimation technique in more details in the following.

Denote the parameters in demand equation (2) as $n = \left(\alpha_k^d, \lambda, \theta^d\right)$ and parameters in pricing equation (4) as $m = \left(\gamma^d, \gamma_k, \gamma(t), \kappa_w\right)$. 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}, Σ^{s-1}, ψ^{s-1}. And unobserved firm shock is denoted as $\left(\omega^{s-1}, \xi^{s-1}\right)$ 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 (2)

$$\ln s_i^d(t) - \xi_i^{d,s-1} = -\alpha_k^d \ln p_i^d(t) + I_i^d(0)\left(\theta^d - \lambda t\right) + u_i^d(t)$$

(2) Conditional on $n^s, \xi^{s-1}, \omega^{s-1}$, we can update m^s from pring equation (4)

$$\ln p_i^d(t) - \ln\left(\frac{\alpha_k^d}{\alpha_k^d - 1}\right) - \omega_i = \gamma^d + \gamma_k + \gamma(t) + \kappa_w \vec{w}_i(t) + v_i^d(t)$$

(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 latend payoff if firm exports (including pioneer decision)

$$V_i^{de}(t) - V_i^{dn}(t) = H\left[\Omega_{i,t}, I_i^d(0) = 1\right] + \hat{\phi}_i^d(t) \tag{1}$$

$$\tilde{V}_i^{de}(t) - \tilde{V}_i^{dn}(t) = H\left[\Omega_{i,t}, I_i^d(0) = 0\right] + \hat{\phi}_i^d(t) \tag{2}$$

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.

[2] W includes a mean and a variance -covariance matrix.

Here $\hat{\phi}_i^d(t)$ denotes the noise term. We normalize its standard deviation to be 1. 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. It contains: (i) Time dummies to capture aggregate demand $\ln Y(t)$; (ii) Destination dummies to capture $C_{uv}^d + \ln Y^d$; (iii) Product dummies to capture $\ln Y_k$; (iv) A term capturing $\left(1-\alpha_k^d\right)\left(\ln \mu_k^d + \gamma^d + \gamma_k + \gamma(t) + \kappa_w \vec{w}_i(t)\right)$; (v) FMA $I_i^d(0)\left(\theta^d - \lambda t\right)$; (vi) Unobserved shocks $\xi_i^d, \left(1-\alpha_k^d\right)\omega_i$.

In the pioneer equation, we approximate the latent payoff equation with a linear function again.

$$V_i^{de}(0) - \tilde{V}_i^{dn}(0) - F_k^d = H_x\left[\Omega_{i,0}, F_k^d\right] + \hat{\phi}_i^d(t) \tag{3}$$

H_x contains: Destination dummies, product dummies, a term capturing $\left(1-\alpha_k^d\right)\left(\ln \mu^d + \gamma^d + \gamma_k + \kappa_w \vec{w}_i(t)\right)$ and unobserved shocks $\xi_i^d, \left(1-\alpha_k^d\right)\omega_i$.

Conditional on n^s, m^s, ω^{s-1}, ξ^{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

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

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

1.A Identify F_k^d and Export Cost ϕ

We need to solve four firm value functions: $V_i^{de}(t), V_i^{dn}(t), \tilde{V}_i^{de}(t)$ and $\tilde{V}_i^{dn}(t)$ which mean pioneer firm value if exports or not exports and follower firm value if exports or not exports.

(1) Given productivity ω^s, ξ^s, then we solve follower firm value function of not exporting by solving the following value function

$$\tilde{V}_i^{dn}(t) = \beta E\left\{\left[\max\left[H(t+1), 0\right] + \tilde{V}_i^{dn}(t+1)\right]\right\}$$

Then $\tilde{V}_i^{de}(t)$ is defined by $\tilde{V}_i^{dn}(t) + H(t)$.

(2) Let $T_x = [\frac{\theta^d}{\lambda}]$ then T_x is the number of periods when pioneer firm FMA disappears. Then pioneer and follower firm tend to be same. Starting from period T_x, we can backward induct to solve pioneer firm as

$$V_i^{dn}(t) = \beta E \left\{ \left[\max \left[H(t+1), 0 \right] + V_i^{dn}(t+1) \right] \right\}$$

and $V_i^{de}(t)$ is defined by $V_i^{dn}(t) + H(t)$.

(3) Comparing the difference between H_x and $V_i^{de}(0) - \tilde{V}_i^{dn}(0)$ then we can identify F_k^d.

(4) We compute expected firm profit $\pi_i^d(t)$ from equation (6). Comparing linear approximation result $H(t)$ and $\pi_i^d(t)$ we have

$$\sigma_\phi \left[\pi_i^d(t) - \phi_i(t) \right] \propto H(t)$$

In other words, latent payoff $H(t)$ is subject to a scaling parameter σ_ϕ to $\pi_i^d(t) - \phi_i(t)$.

(5) We guess the mean of export cost ψ and then compute scaling parameter σ_ϕ by dividing $H(t)$ by $\pi_i^d(t) - \psi$. Then we check the standard deviation of residual $\sigma_\phi \left[\pi_i^d(t) - \phi_i(t) \right]$ to be 1 or not.

1.A.1 Compute Market Failure

We compute market failure in this way.

(1) Start with an initial guess $J(x)$

(2) Get the distribution of x'. In one simulation, fixing the number of entrants N, we randomly draw N firms from the population. From this sample we evaluate H_x and $\tilde{V}_i^{dn}$ at $t = 1$. $V_i^{de}(1) - \tilde{V}_i^{dn}(1) = H_x \left[\Omega_{i,1}, F_k^d \right] + F_k^d$. Then randomly assign ϕ_i to each firm. If planner chooses 1 firm to become pioneer, then he must choose the firm whose $V_i^{de}(1) - \tilde{V}_i^{dn}(1) - \phi_i$ is largest. Let us call this firm as i^*. For all other firms, we define $x_i' = \max(V_i^{de}(1) - \tilde{V}_i^{dn}(1) - \phi_i, 0) + \tilde{V}_i^{dn}(1)$ and firm i^* as $V_{i^*}^{de}(1) - \phi_{i^*}$. Define $x' = \sum x_i$. Evaluate J on x'

(3) Repeat step 2 a larget number of times and get $E_{x'} J(x')$

(4) Update J from

$$J(x) = \max \left\{ x - F_k^d, \beta E_{x'} J(x') \right\} \tag{4}$$

Go back to step 1 until J converges.

	True Parameters	Estimation	std
α	2	1.992	0.0149
θ	0.4	0.7019	0.0915
λ	0.1	0.0888	0.0316
lnY	1	0.9909	0.0268
ρ	0	-0.0181	0.0252
γ^d	0	0.0341	0.0193
γ_k	0	-0.0586	0.0223
γ_w	1	-0.4374	1.1097
ϕ/V_0	0.3388	-0.189	
F/V_0	1.3552	1.5099	-
$std(\xi)$	0.1	0.197	-
$std(\omega)$	0.1	0.206	-

Table 1: Parameters Comparison

(5) Redo step 2 at period $t = 0$ to get $x_i = V_i^{de}(0) - \tilde{V}_i^{dn}(0) - \phi_i$. And $x = \sum \left\{ \max(V_i^{de}(0) - \tilde{V}_i^{dn}(0) - \phi_i, 0) + \tilde{V}_i^{dn}(0) \right\} + V_{i^*}^{de}(0) - \phi_{i^*}$.Then if $\max_{i \in E_0} x_i < F_k^d$, $x > F_k^d + \beta E_{x'} J(x')$. we record 1 market failure.

(6) Repeat (5), then we can count the number of market failure in our simulation.

When we compute the aggregate of market failure across destinations and sectors, we assume when we randomly draw the firm, we do not distinguish the sector and destination in the population sample. In other words, we get a different samples with different composition of market and sector in each simulation.

1.B Evaluate linear approximation

To evaluate the linear approximation, we assign parameters to the model and then simulate sample. Then we use the code to estimate the sample. The results comparison are reported in Table

In the figure 1, we get the probability of market failure using the true parameters and the model prediction. The top left figure is probability of missing pioneer when we use our linear approximation strategy to compute. The top right figure is the true probability of missing pioneer. The bottom two figures are probaility of too many entrants. We can see that results from our linear approximation is quite close to the true figures.

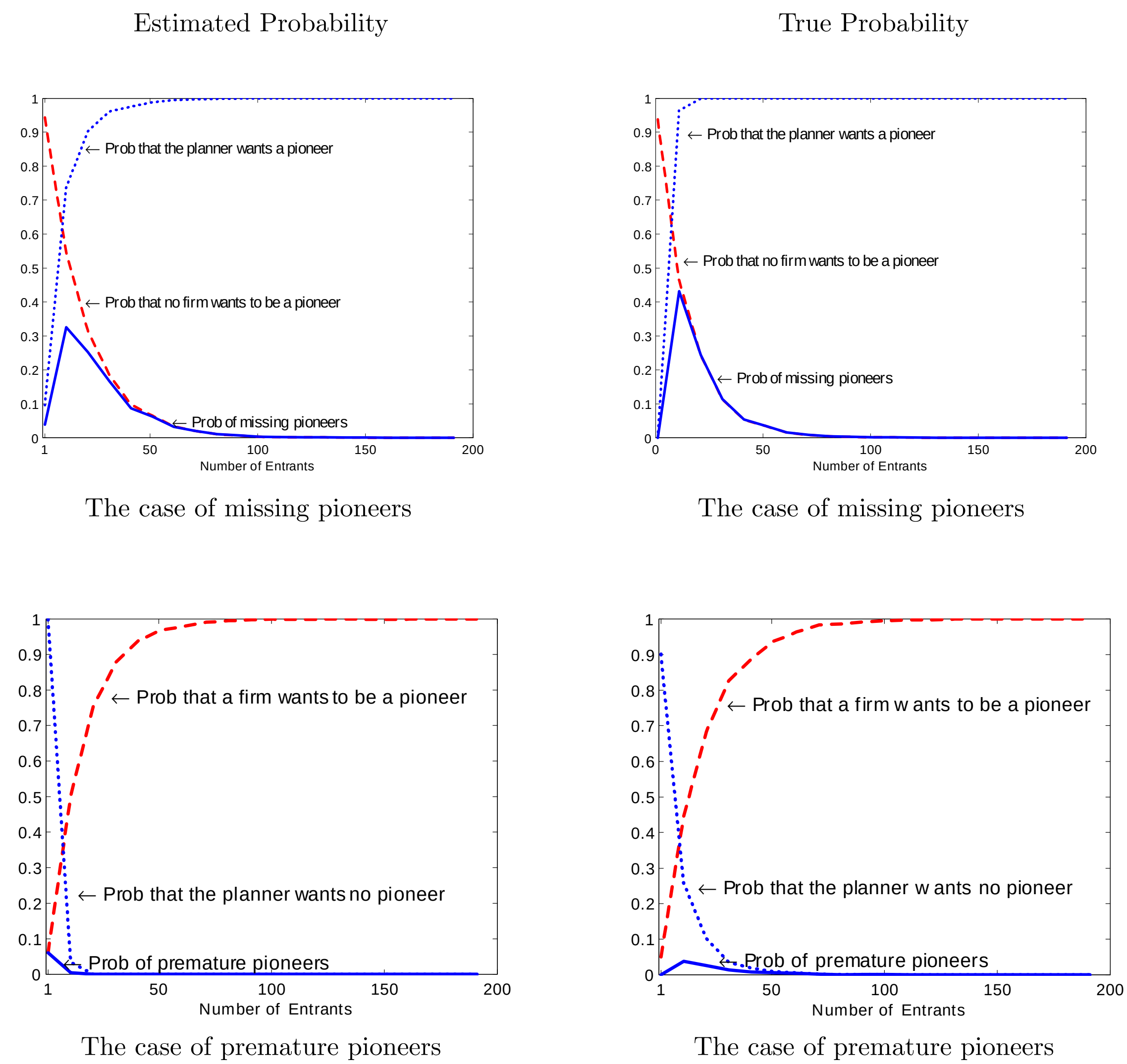


Figure 1: Comparing True and Estimated Probabilities

2 Appendix: Chinese data - Additional Details

2.A 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 70 parameters to estimate in our baseline model even after making a number of simplifying assumptions), 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.)

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 equipment). 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 2000-2002[3]. 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 sales and prices (unit values) evolve. In other words, we identify all the export pioneering activities (593 in total) during 2000-2002 and trace the dynamics of both the pioneers and all followers during 2000-2006.

Importantly, when a product is not exported to a particular destination, some other products (out of our 21) are often still exported to this destination. It is relatively uncommon to have a destination in which none of the 21 products is exported. This feature of the data is important in our ability to identify discovery cost parameters (the sum of a product component and a destination component) and other parameters.

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

[3] We start the Comtrade data in 1996 in order to bypass a reclassification of HS codes from 1995 to1996.

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 2: Sample Distribution of Sector 8525-8528

aid, and remote control apparatus, (3) nine products from HS8527, reception apparatus for radiotelephony etc, and (4) five products from HS8528, television receivers etc. Key features of these four sectors are reported in the first panel of Table 2.

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 was different ex ante. In particular, HS8526 was relatively under-explored by the end of 1999 whereas HS8527 was 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 2.

A firm is called a pioneer if it is the very first Chinese exporter of a particular product to a particular destination. We call all subsequent entrants (for the same product destination pair) as followers. While it is possible to have more than one pioneer firm for a given product-destination pair, it is extremely rare in practice. We find that in 97% of all the newly explored markets during 2000-2003, there is a single pioneer firm; in the remaining 3% of the cases, there are two pioneers. There is never a case with more than two pioneers. Therefore, for practical purposes, it is realistic to assume a single pioneer.

In Table 3, we report the number of Chinese exporters for each of the 6-digit products in our sample. In over 75% of the cases (16/21), the number of exporters exceeds 100. The median and average numbers of exporters are 295 and 394, respectively (table 3). This means that these sectors are fairly

product	total exporters	US/Canada	Other western hemisphere	FSR	Europe	JPN/KOR /AUS/NZL	Rest of 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
HS852691	34	5	1	0	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 3: Average Number of Entrants

competitive and the number of potential exporters is large. For any given destination and product, the number of exporters tends to be substantially lower (often between 3 and 10). This presumably is a result of firms' choices (e.g., in response to destination-specific entry costs).

2.B Descriptive dynamics in the new markets

We now provide some descriptive dynamics of pioneers and followers in the markets that are first explored during 2000-2002. 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 4 summarizes the number of exporters that are ever presented in each new market since its emergence untill the end of 2006, as well as the number of active firms in each period. For each indicator, we report the 90th percentile, the mean and median value. In addition to the full new market

(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 4: 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.

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 4. 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).

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 and Zahler (2013)). In comparison, Melitz-style models tend to imply that a firm with a high productivity is more likely to be a pioneer (see Bernard et al., 2007, and Freund and Pierola, 2012, for evidence in this direction). Table 5 lists some cost and export characteristics of pioneers and followers. Due to data limitations, we only consider three cost variables[4]: (1) whether the firm is a processing exporter, (2) its

[4]The 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

ownership type, and (3) city-level local wage (using data at the year of 2000) where the firm is located. Panel A of Table 5 reports that 40% of the pioneer firms engaged in processing trade, compared with 39% for the followers. Mean comparison test shows the difference between a pioneer and a follower is not statistically significant. The ownership type seems to matter a lot for a 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 differences between pioneers versus followers in terms of 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 domestic private firms and many foreign invested firms had to export through intermediary trading firms, most of which were SOEs. This indicates the role of SOE might be exaggerated.

Panel (b) reports the statistical result based on a sub-sample of firms that are manufacturing firms rather than 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, 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.

Note that in our structural model, we allow a firm's marginal cost to be a

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 5: Comparison between Pioneers vs. Followers

function of firm ownership, whether it is a processing exporter or now, and local wage rate (as well as of its productivity and other terms).

We now report some naive statistics on the dynamics of pioneers and followers for our sample. This is not to replace the subsequent dynamic structural estimation, but to highlight some basic patterns in the data. 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 4).

3 Appendix: Extensions - Additional Details

3.A Dynamic Setup

We extend our benchmark model into a dynamic environment. In the demand equation, we introduce a consumer loyalty effect. In particular, if a firm has exported to a particular market in a previous period, then the demand for its variety is potentially higher in this period:

$$\ln s_i^d(t) = \xi_i^d - \alpha_k^d \ln p_i^d(t) + \rho I_i^d(t-1) + I_i^d(0)\left(\theta_k^d - \lambda_k(t)\right) + \ln Y_k^d(t) + u_i^d(t) \quad (5)$$

In (5), $I_i^d(t-1)$ is an indicator function. It is 1 if the firm exported last period 0 otherwise. Hence ρ captures the idea of consumer loyalty. Note that we do not impose consumer loyalty but merely allow it in our specification. The notion of "consumer loyalty" differs from first mover advantage (FMA). While the FMA can only be enjoyed by the pioneer firm, consumer loyalty applies to follower firms too.

Once we allow consumer loyalty, the firm's decision problem in (8) becomes dynamic. In other words, the export decision in one period will affect the profitability of exporting in the subsequent period. This adds substantial additional complexity to our estimation. To save space, we explain our estimation procedure in an appendix, and do not tabulate the results. We note that the coefficient on consumer loyalty is 0.79 and statistically significant (and all other parameter estimates are similar to the baseline case). Hence we find empirical support for the notion of consumer loyalty. In figure 2, we report the results of market failure. While the estimation is more involved, it turns out the inference on the probabilities of the two types of market failures are similar to the benchmark model.

In order to see more clearly the curve for the probability that conditions hold, we also re-produce the curve in the lower left graph (note that the scale of the vertical axis is now changed to 10 to the power of -3.) The probability of market failure peaks at 11% (when the number of firms =20), decreases to 0 very quickly. In other words, in more than 89% of the cases, the problem of missing pioneers does not occur because some firm find it worthwhile to be a pioneer. Therefore, in spite of clear evidence of positive discovery costs and spillover, market failure of the missing pioneers type is not a high probability event.

In the two graphs in the right column, we trace out the probability of premature pioneers (also labeled as "Type-II market faiulre"). In the upper right graph, we use a long broken line to trace out the probability that at least one firm wants to be a pioneer; this rises as the number of potential exporters increases. We use a short broken line to trace out the probability that the social planner does not want any firm to be a pioneer (in a given period); this is a decreasing function in the number of potential exporters. The solid line traces out the probability of premature pioneers. As we have anticipated, it resembles an inverse U. The probability of type-II market failure peaks at 24% when the number of potential exporters is 50. The lower right graph simply reproduces the curve representing the probability of type-II market failure when the scale of the vertical axis is adjusted.

3.B Shutting Down FMA

To develop some idea for the importance of FMA in our inference, we attempt to artificially shut down the FMA in this section. In the benchmark case, we assume a pioneer firm receives a boost in its export sales at the beginning and then gradually decays to 0. Now we assume in the demand equation (2), $\theta = \lambda = 0$. Hence pioneer firms do not have any advantage at the beginning. The probability of market failure is shown in figure 3. The peak probability is higher than the baseline model, about 16% while the slope of the curve is smaller. When there is no FMA, the probability that no firm wants to be a pioneer increases. Hence it drives the first type market failure increases and the second type market failure decreases.

3.C 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 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

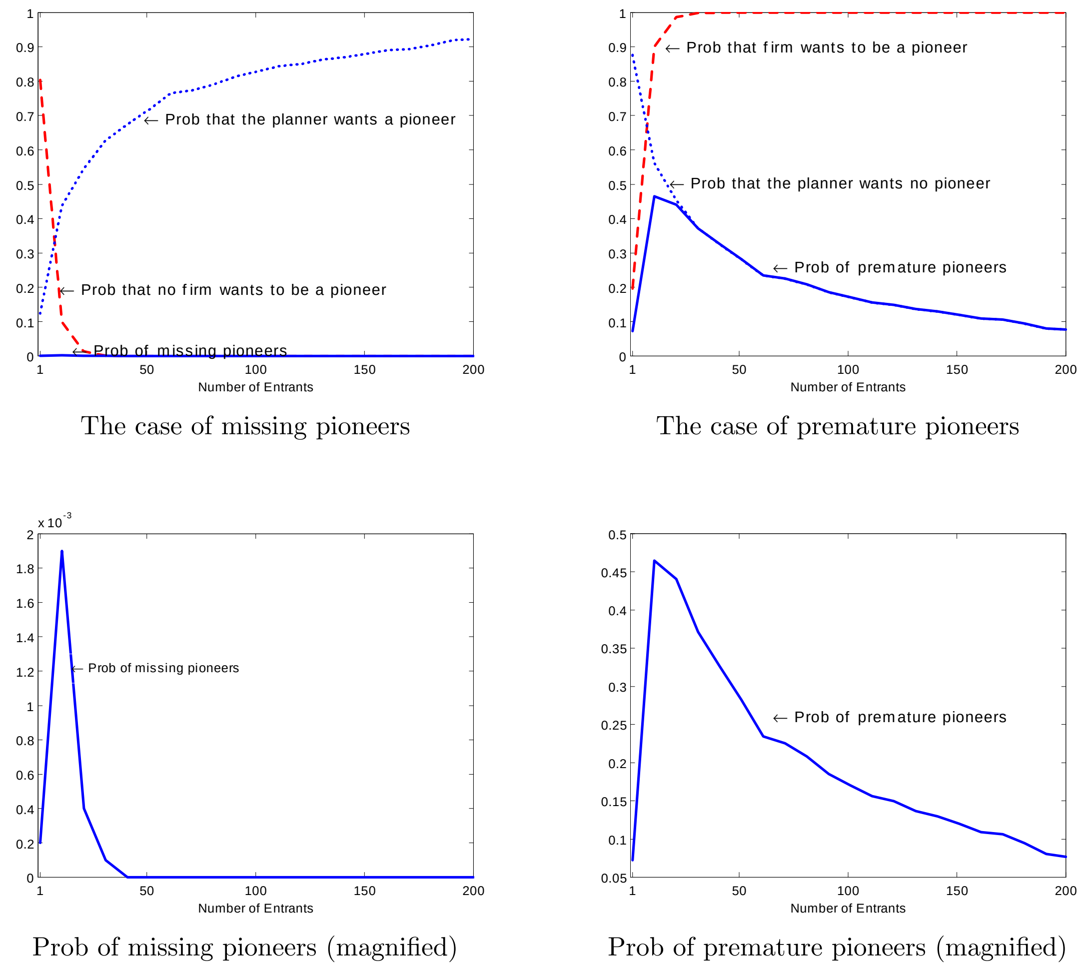
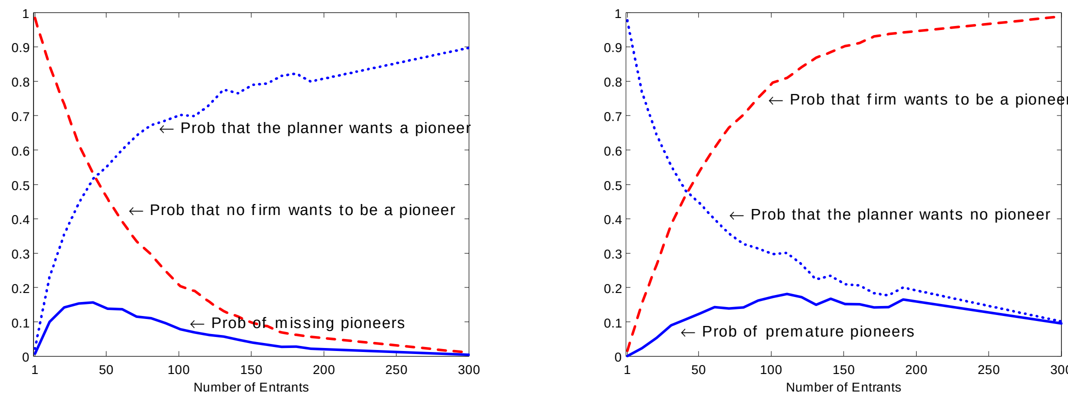


Figure 2: Dynamic model



The case of missing pioneers The case of premature pioneers

Figure 3: Shutting down FMA

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 4. Market failure of missing pioneers is still low in some absolute sense. Comparing these results with the baseline case, it appears that the probability of missing pioneer tends to be a bit lower and probability of too many entrants tends to be higher when we restrict our attention to richer and larger markets.

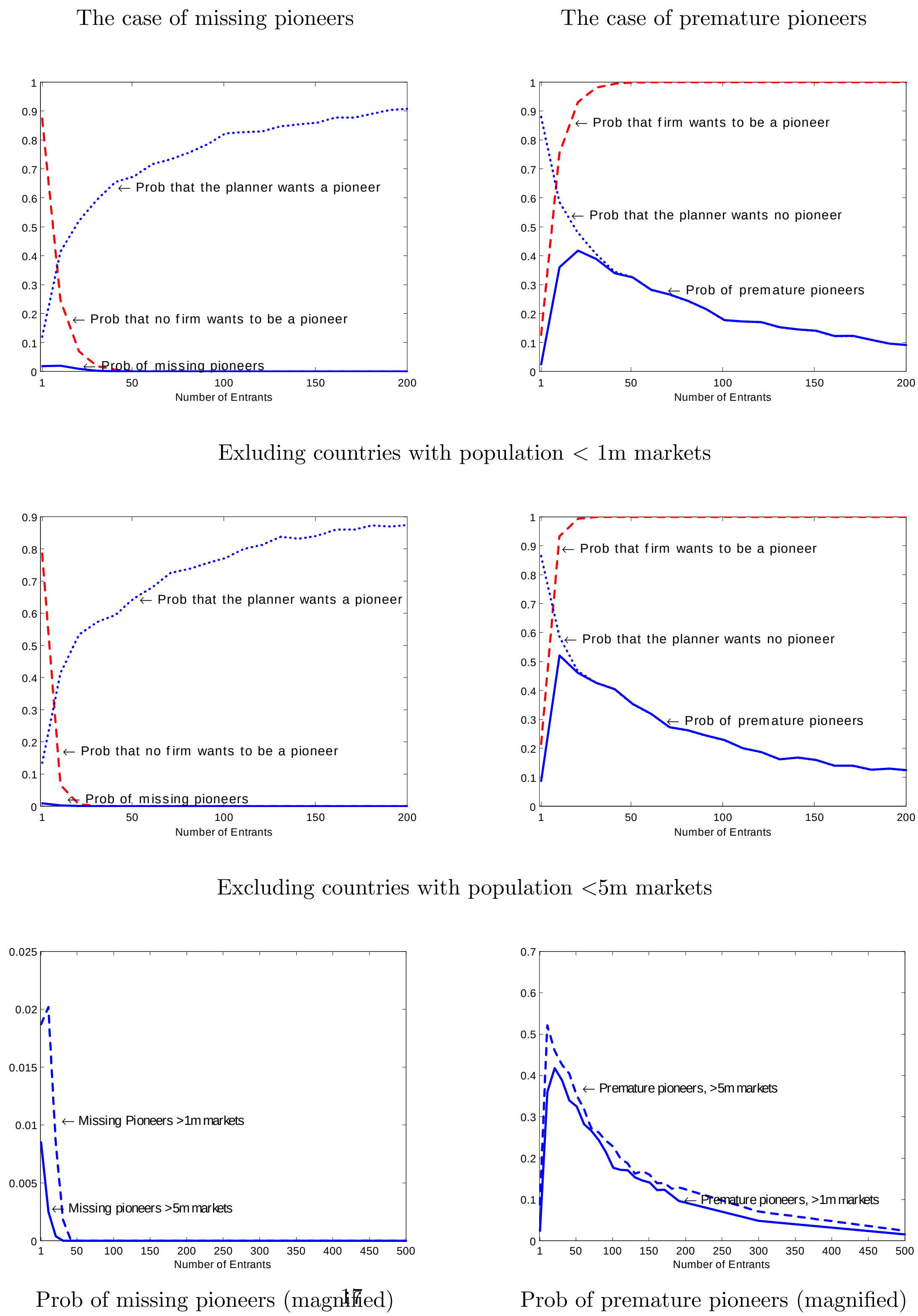


Figure 4: Excluding Smaller Countries

3.D 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 of 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 $\vec{w}_i(t)$ in equation (4)[5]. 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[6]. 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 (10). The set of state variable Ω_i^d now includes these four additional variables[7].

Using the expanded set of structural parameters, we re-compute the probability of market failure and present it in figure 5. It shows that comparing to the benchmark case, probability of missing pioneer increases and probability of too many entrants declines.

3.E 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

[5] In other words, $\vec{w}_i(t)$ contains ownership, wage, processing status and also four additional learning variables now.

[6] Fernandez and Tang (2012) also examines whether learning dissipates with physical evidence but finds no evidence in favor of this hypothesis. For this reason, we do not incoporate this feature. Incorporating such a feature in our non-linear system would have substantially complicated the estimation.

[7] We keep equation (**??**) same and change the equation (**??**) 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 (**??**) and (**??**) are also changed since state variables Ω_i^d are augmented too.

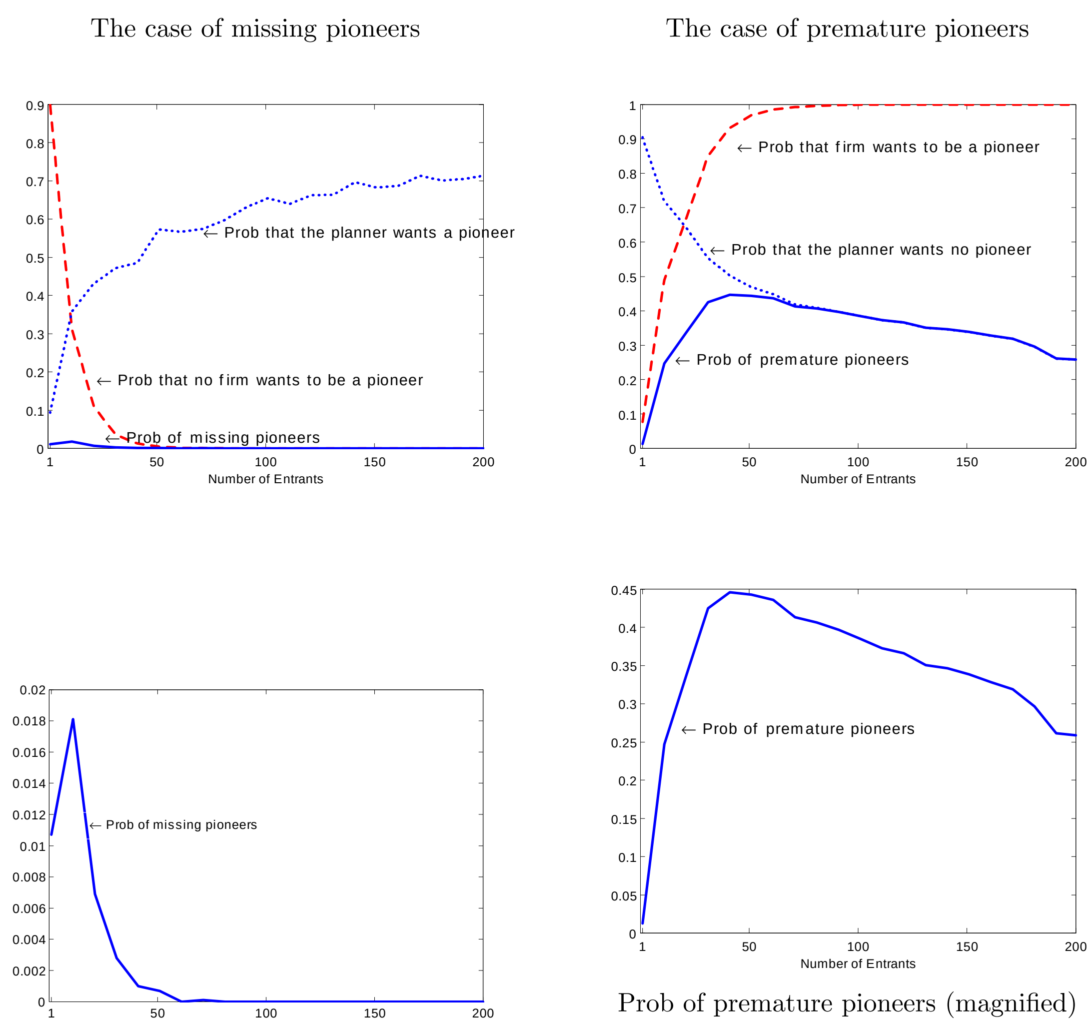


Figure 5: Additional Learning Channels

(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 6. 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. In any case, the probability of missing pioneer 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.

3.F 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 6 shows, there are five common markets during our sample period of 2000-2002[8]. 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.

[8]Member 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.

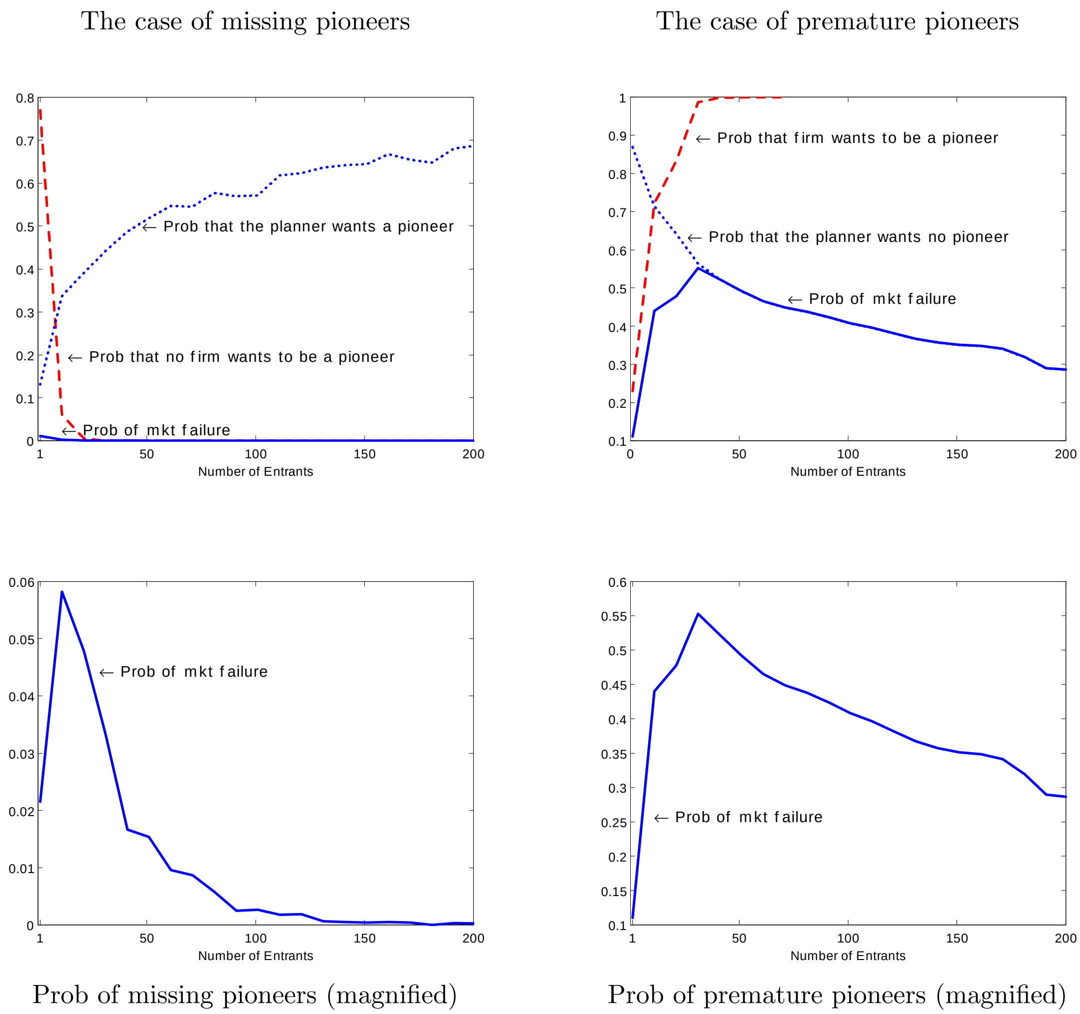


Figure 6: Excluding intermediary firms

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 6: Common Markets in the Year of 2000

Country	Export value (mil USD)		Growth decomposition	
	YR2000	YR2002	Extensive	Intensive
China	7664.164	12600	5%	95%
	[1234]	[1448]		
Brazil	1341.453	1486.028	17%	83%
	[191]	[255]		
India	37.415	64.376	45%	55%
	[232]	[280]		
Japan	14700	15600	3%	97%
	[1385]	[1365]		
Poland	655.624	1134.188	4%	96%
	[86]	[83]		
Czech Republic	347.731	814.687	4%	96%
	[396]	[430]		
Italy	894.722	1187.632	15%	85%
	[1168]	[1253]		

Table 7: Growth Decomposition for China and Other Similar Economics, HS8525 to 8528 (In brackets: Number of product-country pairs)

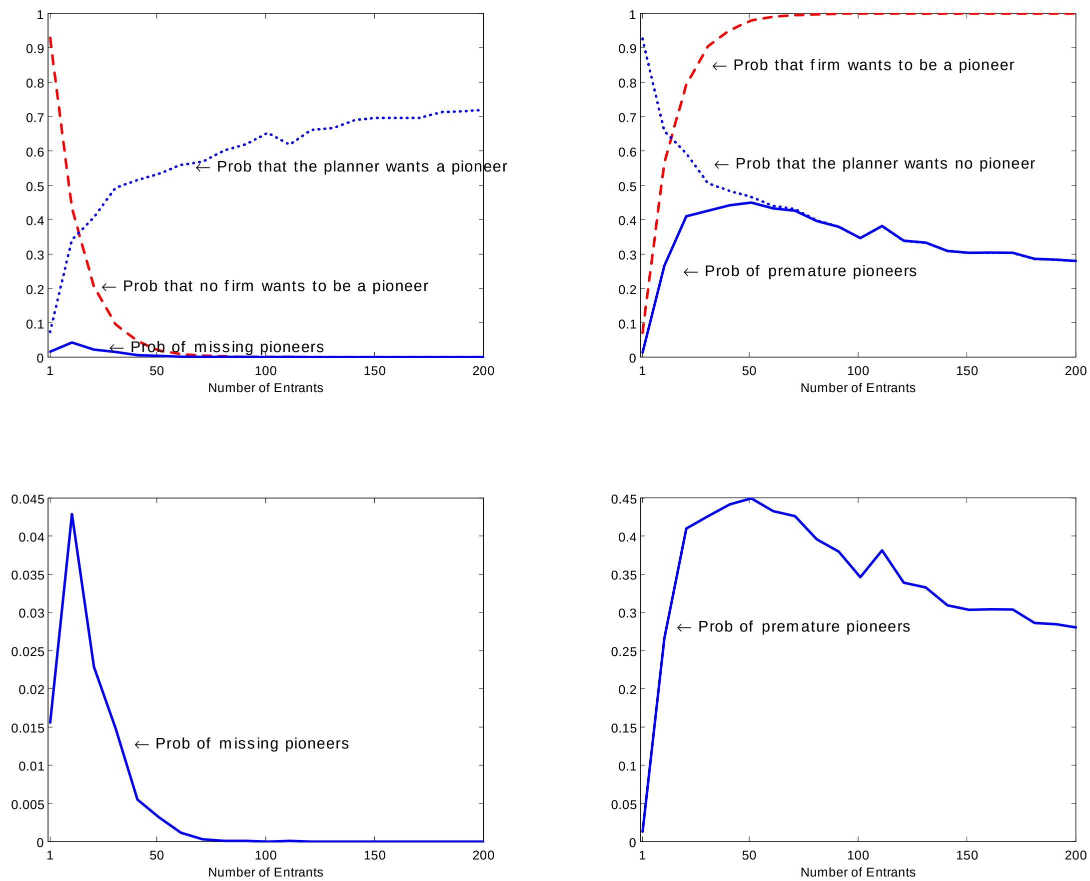
We now investigate the consequence of this assumption for our main conclusion. Specifically, we treat a common market as a single destination country and re-identify markets accordingly. With this new definition of destinations, 444 new markets were conquered during 2000-2002. We re-estimate the structural model, re-compute the probability of market failure, and report the main results in Figure **7**. Compared to the baseline case, we find that this extension also tends to result in a lower probability of missing pioneer.

3.G Possible Biases from Using Chinese Data

The third concern is that China might have superior export performances than other countries in sector 8525 to 8528, resulting in less observed market failure. By superior export performance, we mean the export growth from extensive margin (export to new product-country pairs) might be much greater than that from intensive margin (export to existing product-country pairs) in China than in other similar countries. If this is true, the use of Chinese data would produce a very low and unrepresentative probability of market failure. To check whether such problem exists, we decompose China and its cohorts' export growth from 2000 to 2002 into extensive and extensive margins. The results are listed in Table 7. It is obvious that China didn't stand out in terms of extensive margin growth when compared with Brazil, India, Japan, Poland, Czech, and Italy.

The case of missing pioneers

The case of premature pioneers



Prob of missing pioneers (magnified)

Prob of premature pioneers (magnified)

Figure 7: Treating a Customs Union as a Single Country