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Shang-Jin Wei
Ziru Wei
Jianhuan Xu

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ABSTRACT

We argue that existence of public good does not necessarily imply market failure, and illustrate this point in the context of international trade. An influential hypothesis states that export pioneers are too few relative to social optimum because the first exporter's action creates an informational public good for all subsequent exporters. The hypothesis has been invoked to justify certain types of government interventions. We note, however, that such market failure requires two inequalities to hold simultaneously: the discovery cost is neither too low nor too high. Neither has to hold in the data. We propose a structural estimation framework to evaluate the hypothesis, and estimate the parameters based on the customs data of Chinese electronics exports. Our key finding is that "missing pioneers" are a low-probability event for large countries, but can be a serious problem for small economies.

Shang-Jin Wei
Graduate School of Business
Columbia University
Uris Hall 619
3022 Broadway
New York, NY 10027-6902
and NBER
shangjin.wei@columbia.edu

Ziru Wei
Tsinghua University
Beijng, China
weizr.04@sem.tsinghua.edu.cn

Jianhuan Xu
School of Economics
Singapore Management University
90 Stamford Road, Singapore
xujh03@gmail.com

1 Introduction

We argue in this paper that existence of public goods or externality does not automatically imply market failure, as long as the cost of providing the public good or the investment needed for the activities that generate positive externality has a fixed or lumpy component. We illustrate this point in the context of evaluating empirically an influential hypothesis in international trade. According to this hypothesis, the action of the first exporter - an export pioneer-to a new market is (partly) a public good as it may reduce the fixed cost of entry to the same market for all subsequent exporters. This public good feature is then taken to imply that there would be too few export pioneers in market equilibrium relative to social optimum. We will show that this reasoning is incomplete.

Arrow (1962) may be the first to formally model the notion that if investment by one firm creates knowledge that is a public good that can benefit other firms, then market failure may occur when all firms choose to 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. When a firm exports a product to a new market, it has to incur a cost to find out about local taste, local regulation, and the appropriate amount of "tinkering" that may be needed to make the sale possible. At least a major part of such information cannot be patented or hidden by the pioneer firm, subsequent firms can use it to save entry cost to the market. This implies a gap between the social value of the first discovery and the private value to the pioneering exporter. The existence of such 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, 2013; 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; and Lin, 2012). This hypothesis is very influential. For example, the Hausmann and Rodrik (2003) paper has 1866 citations by Google Scholar count as of September 2017.

Several recent empirical papers provide support for parts of this hypothesis. Freund and Pierola (2010) examine the case of Peruvian exports of nontraditional agricultural products (e.g., asparagus) which did not 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 (2013) 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 the observable action of the first exporter seems to be a public good that benefits 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. To our knowledge, no paper so far has formally estimated the probability of missing pioneers and determined when they may be a low-probability event.

We contend that even if the observable action of the first exporter is a public good, it does not automatically imply missing pioneers and a need for government intervention. Such market failure would require two inequalities to be satisfied simultaneously. First, the discovery cost cannot be too small, or 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 then the public good is produced anyway. Second, the discovery cost for entering a new market cannot be too large, or 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.

Since no presumption exists in the economic theory that either of the two inequalities has to hold, one has to look at the empirical evidence on these inequalities. In other words, even if we know that the action of the first exporter is a public good, we have to empirically find out the values of relevant parameters before we can conclude that the existing market equilibrium is sub-optimal. As far as we know, no existing empirical work has taken this approach. Hence, we are not yet able to judge if "missing pioneers" are a high probability event.

We develop a structural estimation framework to study this question. We apply the framework to micro-data on 21 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 we 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 and other demand and cost parameters. Our data allows us to observe 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.

How do we identify market failure? In particular, since there are many product-destination pairs for which there are zero exports from China, how do we estimate the size of the discovery costs in such markets? How do we know, in cases of zero trade, whether they represent market failure -when the discovery cost is high enough to deter any individual firm to want to be a pioneer but not too high so that the social planner still wants a pioneer? These are some of the important identification questions we have to tackle. Our identification relies on a combination of assumed economic structure and data features. In terms of the economic structure, the discovery costs are allowed to vary by (HS 4-digit) sector and region, but assumed to be the same within a given sector and region. If some countries in a region receive exports of some products within a given sector, the discovery cost for that region and sector can be estimated. In the actual data, while many products are not exported to many countries, there are always some exports of some products to some countries in every region-sector. This helps us to estimate the discovery costs for all region-sectors. Similar assumptions on the structures of demand and cost together with the same data features allow us to uncover all the parameters in the demand and cost functions. Like any research with structural estimation, the assumed economic structure offers us a way to interpret the data patterns. Armed with these structural parameters, we can simulate the expected profits of the firms in any given product destination pair, and then make assessments on the likelihood of market failures.

Interestingly, once we lay out our framework, a different type of market failure could 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. 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.

To preview the main results, we find evidence in support of the notion that the observable action of the export pioneer is a public good. Nonetheless, we find that the probability of "missing pioneers" is only high for small economies but not for large or medium ones. One reason for this result is that the presence of first mover advantage adds an incentive for firms to be an export pioneer. Separately, productivity (and demand) shocks in the data are sufficiently dispersed across firms, which also reduces the probability that no firm wants to be a pioneer. It is important to note that our framework does not pre-determine the answer. Indeed, we show that with a different set of parameter values, "missing pioneers" could become a high-probability event.

While our paper shares some common features with the existing literature by allowing for the public good feature in the first exporter's actions, it differs in four important ways. First, we allow for (but do not impose) first mover advantage. 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 a low probability event for most country-sectors except for the very small ones.

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. 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 the Broader Literature

This paper is related to a larger literature on barriers to trade in new markets. 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. It is interesting to compare this 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 it would export. If exporters are more productive than non-exporters in the Melitz model, one may think that the pioneers are more productive than followers. 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, while on average, pioneer firms tend to have a high productivity level, a less productive firm with a lucky draw of a low fixed entry cost could sometimes enter a new destination ahead of an otherwise more productive firm but with an unlucky draw of a high fixed entry cost.

Note that none of the theoretical papers formally states that the existence of discovery cost and externality 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 (2013). The key takeaway from these analytical case studies is that the first exporter does appear to pay an extra cost to enter a market than the subsequent exporters. 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 (2013) and Wagner and Zahler (2011) also show data patterns that are consistent with the notion that the first exporter's action is a public good. In particular, once a pioneer becomes successful, they show that imitators tend to emerge relatively quickly. Fernandes and Tang (2014) provide both a model and evidence from China that exporting firms benefit from observing the successes and failures of other firms. When they test if a firm benefits more from a nearby firm or a far-away one, they find no statistically significant evidence that distance matters. Why is this the case? If trade associations, trade shows, and industry conferences at the national level are the primary channels for understanding foreign markets, then distance within a country may matter much less.

We can connect the current discussion on whether an exporter pioneer produces a public good (knowledge about a new foreign market) to another literature on informational barriers to trade. Rauch (1996, 1999, and 2001), Rauch and Trindade (2002), and Casella and Rauch (2003) 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 knowledge about a foreign market is a public good, diplomatic services, government-sponsored trade missions, and export promotion agencies could play a useful role. 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 producing a public good. 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 for 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 the two types of market failures. In this sense, our paper fills an important void in the literature.

3 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.

As a notational convention, we use $t = 0$ to denote a period in which no pioneer has appeared as of then and firms have to decide if they wish to be a pioneer in that period.

It is important to note that, while we follow Hausmann and Rodrik (2003) and use the term "discovery cost," the action of the export pioneer is modeled as a public good. The fixed entry cost for a firm to export a good to a market has two pieces: one is a standard entry cost that any firm needs to pay, but the other is something only the very first exporter needs to pay (which is the discovery cost). In other words, the first exporter's action reduces the total fixed cost of entry that subsequent firms need to pay. The first exporter cannot patent the knowledge about the foreign market, and the use of the knowledge by one follower does not preclude the usage by other followers. Note that we do not need to assume that everything that the first exporter has learned becomes a public good. Rather, the observable action of the first exporter is a public good. The part that is not a public good belongs to the remaining part of the entry cost that every firm still needs to pay.

Note that our specification does not mechanically assume that the public good feature has to exist; the estimate of the discovery cost can be zero or even negative in principle. Finding a positive discovery cost empirically will be interpreted as finding evidence of public good. It is also important to note that we do not model the problem as a learning problem. Due to the complexity of introducing learning in a dynamic structural model with an unrestricted number of potential entrants, we leave it to future research.

The assumption that the discovery cost is paid for only by the first exporter but not by subsequent ones is also significant. If the discovery cost needs to be paid by all firms, say on a declining scale based on the timing of entry to the market, then, the payoff to a firm depends on the actions of other firms. This would make the problem substantially more complex. In comparison, if the discovery cost is paid only by the first exporter, then only the payoff in t=0 depends on the actions of other firms. In other words, the problem after the first period becomes a static game.

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

$$\ln s_i^d(t) = \delta_i^d(t) + \ln Y_k^d(t) \tag{1}$$

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

as:

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

The first term, ξ_i^d, is a firm-specific demand component. The second term, $p_i^d(t)$, is the price paid by consumers in destination d for variety i in period t. The third term, $I_i^d(0)\left(\theta_k^d - \lambda_k(t)\right)$, 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 product-destination specific term θ_k^d, and it decays over time at a rate of $\lambda_k(t)$ (until $\theta_k^d - \lambda_k(t)$ 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.

An important assumption we make here is that the number of firms does not enter the demand equation directly. The number of firms can affect the demand indirectly via its effect on the price index for that market, and the price index is absorbed into the destination, sector, and time fixed effects. The setting we have in mind is that, while the number of entrants from a particular exporting country may be small, the total number of sellers in the destination country from all countries is big. In that setting, the assumption can be justified by a Dixit-Stiglitz-like utility function for variety or monopolistic competition. In any case, this assumption will vastly simplify the subsequent firm optimization problem and help us to avoid discussing strategic interactions among firms.[1]

One interpretation of the FMA as we have specified is that it is a favorable shock to the taste - the demand for the variety of the first exporter from a given country - that lasts for a few periods but not forever. (In the context of Dixit-Stigliz utility function, the FMA specification can be thought of as capturing the evolution of the preference parameter for the pioneer firm). Note that we do not assume that the two parameters in FMA have to be non-zero. We will

[1]In the existing literature, there are papers (e.g., Aguirregabiria, 2010) that solve for strategic interactions when the number of firms is relatively small but not when it is large or unrestricted. As we will show later, the potential number of exporters in our sample will be in the hundreds; it will be nearly impossible to allow for strategic interactions and we choose to avoid it.

let the data tell us what they are.

$H_i(t)$ is a set of firm characteristics that may be correlated with product quality (such as firm ownership) and ρ is an associated vector of coefficients. The last term, $u_i^d(t)$, is a random noise, whose distribution will be specified later.

Combining the previous two equations, the sale for variety i in destination d, in logarithm, takes the following form:

$$\ln s_i^d(t) = \xi_i^d - \alpha_k^d \ln p_i^d(t) + I_i^d(0)\left(\theta_k^d - \lambda_k(t)\right) + H_i(t)\rho + \ln Y_k^d(t) + u_i^d(t) \quad (3)$$

Equation (3) 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 additional 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 need 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:

$$\ln c_i^d(t) = \gamma^d + \gamma_k + \gamma(t) + W_i(t)\kappa + \omega_i + v_i^d(t) \quad (4)$$

γ^d is a fixed effect component that is common to all firms in a given destination, whereas γ_k is a fixed effect component 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.

$W_i(t)$ 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). Another example is whether a firm is a processing exporter or not; a processing exporter can enjoy tariff exemption on imported inputs and may therefore enjoy a cost advantage over normal exporters. We also include a set of ownership dummies for wholly foreign owned firms, joint ventures, and state-owned firms; the omitted group is domestic private firms. The ownership dummies are meant to capture two things. First, they can be proxies for quality. In particular, relative to the varieties produced by domestic private firms, if those produced by foreign-owned firms or state-owned firms are of higher quality, they may require better and more costly inputs. Second, if state-owned firms have privileged access to cheap credit, they may have a lower cost of production than otherwise. κ is the coefficient of $W_i(t)$.

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.

Between the demand and the cost functions, there are four random variables. We assume ω_i and ξ_i^d are observed by the firm but not by the researcher. $v_i^d(t)$ 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.

Assuming all firms operate in a monopolistically competitive industry, a profit-maximizing firm facing the demand in equation (2) will charge a price of

$$\ln p_i^d(t) = \ln\left(\frac{\alpha_k^d}{\alpha_k^d - 1}\right) + \gamma_k^d(t) + W_i(t)\kappa + \omega_i + v_i^d(t) \tag{5}$$

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, $\gamma_k^d(t) = \gamma^d + \gamma_k + \gamma(t)$, a firm-specific cost term $W_i(t)$, and an unobserved productivity shock 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 is assumed to be the same across all products and destinations.

3.3 The Firm's Problem

We first consider a mature market, i.e., one that has already been explored by some exporting firms (i.e., 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 virgin 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.

Note if either the demand or the cost function of a firm were to depend the number of firms in the market, then the payoff and entry/exit decisions of a firm would depend on the entry/exit decisions of all other firms in each period. Because the potential number of firms is large in our sample, and the firms are heterogeneous, this problem is impossible for solve, and no papers in the existing literature has solved such a problem in the case of a large number of firms. Under our assumption that neither the demand nor the cost function of a firm depends on the number of firms, we can simplify the problem sufficiently to make it solvable. In this case, only the pioneer firm's payoff (and entry and exit decisions) may depend on other firms' actions. For all follower firms, the payoff (arnd the entry and exit decisions) are independent of other firms' entry/exit actions. Note that a pioneer firm's problem after the first period is identical to that of a follower firm.

3.3.1 To Be an Exporter or Not ?

Consider a mature market in which a pioneer already exists. The timing of firm i is as follows: at the beginning of period t, it observes firm-specific cost shifters $\vec{w}_i(t)$, the destination, product, and period cost shifters $\gamma_k^d(t)$, and the aggregate demand shifters $Y_k^d(t)$. The firm i also knows the permanent productivity component ω_i and the permanent demand component ξ_i^d. For a given destination and a given time period, a firm draws an entry cost $\phi_i^d(t)$ from a normal distribution with parameter ψ.[2] Based on this information, the firm

[2]Although we call ϕ an entry cost, it can take a negative value (e.g., from an export subsidy).

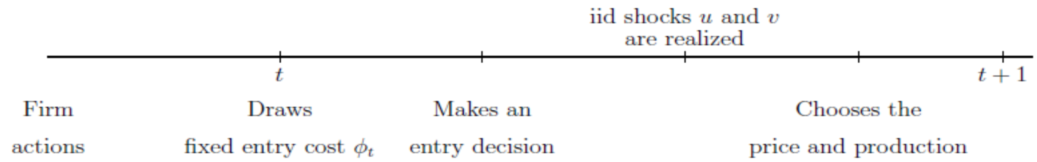

Figure 1: Timing Assumption

chooses to export or not. Transitory shocks $u_i^d(t)$ and $v_i^d(t)$ will be realized after i makes the export decision. Figure 1 shows the timing of the firm problem.

For a representative firm i, the expected profit before paying the entry cost is[3]

$$\pi_i^d(t) = E_{u,v}\left[s_i^d(t)\left(p_i^d(t) - c_i^d(t)\right)\right] \tag{6}$$

The firm will choose to export to that particular market if and only if

$$\pi_i^d(t) > \phi_i^d(t) \tag{7}$$

Denoting $\mu_k^d = \frac{\alpha_k^d}{\alpha_k^d - 1}$ and combining with the pricing and demand equations before, we obtain the firm's log expected profit as

$$\ln \pi_i(t) = \ln a_i + \ln r_i(t) + \ln b_i(t) \tag{8}$$

where

$$\ln a_i = \ln\left(\frac{1}{\alpha_k^d}\right) + \left(1 - \alpha_k^d\right)\ln \mu_k^d + \ln E_{u,v}\left[\exp\left(u + \left(1 - \alpha_k^d\right)v\right)\right] + \xi_i^d + H_i(t)\rho + \left(1 - \alpha_k^d\right)\omega_i \tag{9}$$

$$\ln r_i(t) = \ln Y_k^d(t) + \left(1 - \alpha_k^d\right)\left[\ln \gamma_k^d(t) + \ln W_i(t)\kappa\right] \tag{10}$$

$$\ln b_i(t) = I_i(0)(\theta - \lambda t) \tag{11}$$

In equation (8), the first term is a term that captures all time invariant components. The second term, $\ln r_i(t)$, captures all factors that are random in different periods. It includes both the aggregate demand and marginal cost terms. The last term, $\ln b_i(t)$, captures the first mover advantage. Hence we can summarize the firm's state variables as $\Omega_t = \{a_i, r_i(t), b_i(t)\}$.[4]

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

[4] More formally, the set of firm state variables should be $\Omega_i^d(t) = \left\{\xi_i^d, \omega_i, \vec{w}_i(t), \bar{Y}_k^d(t), b_i^d(t), \phi_i^d(t)\right\}$

Assumption: $r_i(t)$ is a Markovian process.

Given that $r_i(t)$ is a Markovian process, $b_i(t)$ has a deterministic evolutionary rule, and $\phi_i^d(t)$ is an iid shock**,** we can define the firm value by a recursive formula

$$V\left(\Omega_t, \phi_i^d(t)\right) = \max\left[\pi_i(t) - \phi_i^d(t), 0\right] + \beta E\left[V\left(\Omega_{t+1}, \phi_i^d(t+1)\right) | \Omega_t\right], \quad t \geq 1 \tag{12}$$

The right hand side of equation (12) has two parts. The first part says that by choosing to export to this market today, the firm can obtain a current profit of $\pi_i^d(t) - \phi_i^d(t)$. The second part is the discounted future value where the discount factor is $\beta \in (0, 1)$. The solution to the problem is a cutoff rule: if $\phi_i^d(t)$ is smaller than a cutoff value $\bar{\phi}_i^d(t)$, then the firm will export.

Note that the firm value depends on whether the firm is a pioneer or not, as that would affect whether the firm obtains the FMA, $b_i(t)$. We use V^P and V^F to denote the firm values for a pioneer and a follower, respectively.

3.3.2 To Be a Pioneer or Not ?

Let us now consider a firm's optimization problem in a virgin market not yet explored by a pioneer. We use $\bar{V}^P$and $\bar{V}^F$ to denote the firm values of being a pioneer and a follower, respectively. We use $\bar{V}$ to denote the firm value before making the pioneer/follower decision. We denote the time period by $t = 0$. The firm problem differs from (12) in two aspects. First, if firm i chooses to export in period 0, it needs to pay a discovery cost D_k^d that varies by sector and region (on top of a random generic entry cost that needs to be paid by any exporter in any market and period). Second, it will obtain a first-mover-advantage if it decides to be a pioneer. Hence, the expected value for a firm that decides to be a pioneer is:[5]

$$\bar{V}^P\left(\Omega_0, \phi_i^d(0)\right) = \pi_i^d(0) - \phi_i^d(0) - D_k^d + \beta E\left[V^P\left(\Omega_1, \phi_i^d(1)\right) | \Omega_0\right] \tag{13}$$

However, if the firm chooses not to be a pioneer in $t = 0$, the problem is more complex. The firm's payoff depends on the actions of other firms. We denote the distribution of individual firm states Ω_0 as f_0. We use χ to denote the probability that at least one firm will become a pioneer in the next period. As long as some firms are known to want to export in the next period, $\chi = 1$;

[5] The payoff of choosing to become a pioneer does not depend on other firms' actions.

otherwise $\chi = 0$. Notice that χ depends on f_0. Given the policy functions of the firms, χ is a determinstic function of f_0.

For a firm that chooses not to be a pioneer in $t = 0$, its payoff is a convex combination of two possibilities: (1) if another firm becomes a pioneer next period ($\chi = 1$), it obtains the value of a follower firm $\beta E\left[V^F\left(\Omega_1\right)|\Omega_0\right]$; and (2) if no other firm becomes a pioneer ($\chi = 0$), its expected payoff is $\beta E\left[\bar{V}\left(\Omega_1, f_1\right)|\Omega_0, f_0\right]$, since it will face the exact same choice next period of whether or not to become a pioneer.[6] Then the expected firm value if it does not export is

$$\bar{V}^F\left(\Omega_0, f_0\right) = \beta\chi E\left[V^F\left(\Omega_1\right)|\Omega_0\right] + \beta\left(1-\chi\right) E\left[\bar{V}\left(\Omega_1, f_1\right)|\Omega_0, f_0\right] \tag{14}$$

Hence the firm's optimization problem at $t = 0$ is

$$\bar{V}\left(\Omega_0, f_0\right) = \max\left\{\bar{V}^P, \bar{V}^F\right\} \tag{15}$$

To simplify the matter, we focus on a pure strategy in a symmetric equilibrium. That is, every firm has a similar cutoff rule. For a given firm, if and only if its entry cost is lower than its cutoff value, $\tilde{\phi}_i^d$, will it choose to export.[7] We determine that $\chi = 1$ if at least one firm's export cost draw is lower than $\tilde{\phi}_i^d$, and 0 otherwise. Decisions by other firms affect a firm's decision only in period $t = 0$. Note that from $t = 1$ onwards, the model is in a monopolistic competitive environment and other firms' actions can not affect the firm's profit any more.[8]

We use G to denote the cdf of an normal distribution.

$$\Pr\left[\phi_i^d\left(t\right) \leq \bar{\phi}_i^d\left(t\right)\right] = G\left[\bar{\phi}_i^d\left(t\right)\right] \tag{16}$$

$$\Pr\left[\phi_i^d\left(0\right) \leq \tilde{\phi}_i^d\right] = G\left[\tilde{\phi}_i^d\right] \tag{17}$$

Equation (16) says that the probability of exporting (to a particular destination) at time t is equivalent to the firm drawing an entry cost lower than $\bar{\phi}_i^d\left(t\right)$, which is a function of state variable $\Omega\left(t\right)$. Similarly, as shown in (17), the cutoff value $\tilde{\phi}_i^d$ for the decision to be a pioneer is a function of $\Omega\left(0\right)$, and

[6] Since the demand and cost shifters are assumed to be a Markovian process, Ω is a Markovian process. As a result, the distribution of Ω is also a Markovian process.

[7] There might be multiple equilibria if we do not restrict attention to symmetric equilibrium.

[8] We allow multiple firms to be pioneers. But the number of pioneers does not change the profits of any firm since the profit functions do not depend on the number of firms on the market.

the probability of becoming a pioneer, $G\left[\tilde{\phi}_i^d\right]$.

3.4 From the Social Planner's Problem to Market Failures

In this section, we formally consider a social planner's optimization problem. The planner could require all entrants to share the discovery cost (regardless of the sequence of entry). A market is now worth entering as long as the social value (or the sum of the value of all entrants) is higher than the discovery cost. Let us assume that the social planner always asks the most profitable firm to be the pioneer. We show that this determines a lower cut-off point of productivity for export pioneering to take place than in a decentralized economy.

We assume the social planner's objective is to maximize the total value of all firms in this economy. She does so by choosing whether to ask a firm to enter the market $I_i^{Pd}(t) \in \{0,1\}$. The total value of the firms can be thought of as the sum of firm values across products and destinations. For a given product and destination, her optimization problem is:

$$\max_{I_i^{Pd}(t)\in\{0,1\}} E_0 \sum_i \left\{ \sum_{t=0}^{\infty} \beta^t \left[\pi_i^d(t) - \phi_i^d(t)\right] I_i^{Pd}(t) \right\} - I_i^{Pd}(0)\, D_k^d \tag{18}$$

s.t. (8)

Inside the big bracket is the discounted export profit for firm i, which has two parts. The first part, $\pi_i^d(t)$, is the same firm profit before paying the entry cost as in Equation (8). If firm i is chosen by the planner to export at time t ($I_i^{Pd}(t) = 1$), then it also needs to pay a fixed export cost $\phi_i^d(t)$. The last term (outside the big bracket) says that firm i must also pay the discovery cost D_k^d if it is chosen to be a pioneer.

Once a pioneer has been chosen (which is defined to be an event in period 0), the discovery cost is paid and the FMA is assigned. As a result, there are no other potential sources of market failure. For this reason, the rest of the planner's decision rule (about whether any given firm should export or not in each subsequent period) would be exactly the same as what the firms would have chosen on their own in a decentralized market.

Under the assumption in section 3.3 that all shifters in the demand and cost functions follow a Markovian process, the planner's problem is recursive: the distribution of individual states in one period f_1 only depends on the distribution in the immediate past period f_0. We can rewrite the planner's problem as:

$$J(f_0) = \max_{I_i^{Pd}(t)} \sum_i \{ \left[\pi_i^d(0) - \phi_i^d(0) - D_k^d \right] I_i^{Pd}(t) + \beta \left(\sum_i I_i^{Pd}(t) \right) E\left[V^P(\Omega_{i,1}) \right] \} + \beta \left(1 - \sum_i I_i^{Pd}(t) \right) E\left[J(f_1) | f_0 \right] \quad (19)$$

s.t. (15).

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 in which no firm is chosen to be a pioneer. Let x be the value of the first term.

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

$$x - D_k^d > \beta E\left[J(f_1) | f_0 \right] \quad (20)$$

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

$$\eta_k^d = \Pr \left[\begin{array}{c} \max_{i \in E_0} \phi_i^d(0) - \tilde{\phi}_i^d < 0, \\ x > D_k^d + \beta E\left[J(f_1) | f_0 \right] \end{array} \right] \quad (21)$$

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 (19) and when the firm would want to be a pioneer on its own in a decentralized equilibrium (15). That is, the planner would want a pioneer as long as the total gain of all firms x is greater than $D_k^d + \beta E\left[J(f_1) | f_0 \right]$. Because the planner and the firms are not solving the same optimization problem, there is a potential for market failure. In the decentralized market, only if there is at least one firm whose draw of entry cost is lower than the cutoff value, will the firm enter. We define "missing pioneers" as an event when condition (21) is satisfied.

In principle, a different kind of market failure can emerge. In particular, there may be times when the social planner does not wish to have any firm to be a pioneer (by asking all firms to wait for one period), yet at least one firm wants to be a pioneer in a decentralized economy. This problem of "too many pioneers" or "premature pioneers" is the opposite type of market failure that Hausman and Rodrik (2003) stresses. The problem of "too many pioneers" occurs when

$$\varphi_k^d = \Pr \begin{bmatrix} \max_{i \in E_0} \phi_i^d(0) - \tilde{\phi}_i^d > 0, \\ x < D_k^d + \beta E[J(f_1)|f_0] \end{bmatrix} \tag{22}$$

As an example of the second type of market failure, sometimes the highest-productivity draw and the lowest-entry-cost draw are such that some firms find their individual expected profits good enough and would want to be a pioneer now. Yet, the central planner knows the the productivity and entry cost draws are likely to be more favorable in the next period given their distributions and therefore would want all firms to wait for a period. When this occurs, a pioneer firm could emerge prematurely relative to the social optimum.

We now explore some qualitative relationships between the probabilities of these two types of market failures and the number of potential exporters in E_0. We can reason that both η_k^d and φ_k^d depend on the number of potential exporters in E_0, and the relationships are non-monotonic. To see the intuition for the non-monotonicity, let us first consider the case of a single exporter in E_0. Since the firm and the planner have to solve the same problem, there is no market failure of either type by construction. Now consider the case in which the size of E_0 increases. As more firms take draws from the productivity, demand, and entry cost distributions, the chance that at least one firm will get favorable draws increases. This means a declining probability that $\max_{i \in E_0} \phi_i^d(0) - \tilde{\phi}_i^d < 0$, while at the same time, an increasing probability that $x > D_k^d + \beta E[J(f_1)|f_0]$. Therefore, when the number of potential entrants is very large, there should be very low probability for either type of market failure. Market failures are more likely to occur for intermediate values of E_0. We will verify this intuition later.

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 $s_i^d(t)$. Of all the firms that export to a particular market, we can easily tell which one is the pioneer and which ones are the followers. Let us denote the entire data set as D_f. Our empirical model consists of four structural equations: a demand equation (3), a pricing equation (5), an export decision rule (16) and a pioneer decision rule (17). 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 can be devided into two steps. Intuitively, we first estimate ω_i and ξ_i^d using data on an individual firm's prices and quantities. Second, conditional on a set of demand and cost parameters, we estimate the fixed entry cost from the MLE. Details of the estimation procedure are explained in Appendix A.

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, it is wise for us to focus on a subset of sectors. (Even after making a number of simplifying assumptions, we will still have 131 parameters to estimate in our baseline model.)

In this paper, we work with the Chinese exporters of 21 electronics products spanning four 4-digit sectors (HS8525-8528) or 21 6-digit products 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 C.

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 during 1996-1999 but did during 2000-2002.[9] 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 the 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

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

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 21 in our sample) 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.

In Appendix Table 2, 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 product, and the discovery costs are assumed to vary by sector and region. 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 6 destination regions according to their geographical and socioeconomic features: (i) the Western Hemisphere, (ii) Former Soviet Republics (FSR), (iii) Europe (excluding FSR countries), (iv) Japan, Korea, Australia, New Zealand, (v) Rest of Asia, and (vi) Africa. We assume all countries within the same region share the same coefficients. For similar computational considerations, Roberts et al. (2012) had to make comparable simplifying assumptions. (As noted earlier, even with these simplifications, we still have 131 parameters to estimate.)

These parameters are summarized as follows. In the demand equation, we have: (1) 6 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) 6 destination-specific parameters for FMA, θ^d; (4) 1 linear decay rate (λ); (5) 3 firm specific demand shifters, including firm ownerships (state owned, joint venture, and foreign owned); (6) 13 aggregate demand dummies (sector/destination/year, 3+5+5=13). In the pricing equation, we have: (7) 6 destination-specific cost shifters (γ^d); (8) 3 product-specific cost shifters (γ_k); (9) 4 time-specific cost shifters $\gamma(t)$; (10) 6 other cost shifters, $W_i(t)$, including firm ownerships (state owned, joint venture, and foreign owned, with "domestic private" as the left-out group), status of processing trade, status of intermediate trader, and average wage in the city where a firm is located (the average is computed excluding the firm's own wage). We also have: (11) 8 parameters associated with the four random variables in the model (permanent and transitory demand and productivity shocks in equation (3) and (5)). Finally, in the export and pioneer decision rules, (12) there are 24 discovery cost parameters (for 4 sectors x 6 regions) and 48 export cost parameters (mean and variance for each of the 24 sector-region).

Before we present the estimation results, it may be helpful to discss intuitively the sources of identification for some key parameters. The parameter for the first mover advantage, θ^d, is identified via the differences in sales between a pioneer and followers over time. The fixed discovery cost, F_k^d, is identified by the expected profit of the pioneer firms. What happens if there are zero exports from China in certain product-destination pairs? How do we estimate the size of the discovery costs in such markets? Our identification relies on a combination of assumed economic structure and data features. In terms of the economic structure, the discovery costs are allowed to vary by (HS 4-digit) sector and region, but assumed to be the same within a given sector and region. If some countries in a region receive exports of some products within a given sector, the discovery cost for that region and sector can be estimated. In the actual data, while many products are not exported to many countries, there are always some exports of some products to some countries in every region-sector. This helps us to estimate the discovery costs for all region-sectors. Similar assumptions on the structures of demand and cost together with the same data features allow us to uncover all the parameters in the demand and cost functions in all markets.

5.1 Demand and FMA Estimates

Table 1 reports the estimates of the demand equation parameters (equation (3)). In our estimation, to mitigate concerns with endogeneity, we will replace $p_i(t)$ by the average of the export prices of the same product by different firms in different destinations. This is in the spirit of the instrumental variable idea proposed by Hausman et al. (1997) and commonly applied in the empirical industrial organization literature. The first panel of Table 1 reports price elasticities α_k^d. For example, the price elasticity for sector 1 in Western Hemisphere is -4.70, indicating that an increase in price by one percent is associated with a decline in export sales by 4.70%; 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 two regions (Former Soviet Republics and Rest of Europe). The point estimates for the initial FMAs range from 0.43 for the Rest of Asia to 1.21 for the Rest of Europe. A linear per-period decay rate λ is estimated to be -0.06; while it has the expected sign, it is not statistically significant.

The demand for the varieties produced by foreign invested firms, joint ventures, and state-owned firms are higher than that by domestic private firms. This may reflect the higher quality associated the products from the first three types of firms.

5.2 Pricing Equation Estimates

Table 2 reports parameter estimates of the pricing equation (equation (5)). The coefficient on processing exporters is negative and statistically significant. Their lower marginal cost probaby reflects their advantage in tariff exemption for imported inputs. Intermediary exporters also have a lower marginal cost. Wholly foreign owned firms (FIE), joint ventures (JV) and state-owned firms (SOEs) exhibit a higher marginal cost than domestic private firms (the left-out group), probably because they use more expensive inputs to produce output of higher quality. SOEs' higher marginal cost could come from an altogether different reason - their relative lack of efficiency.

Note that processing exporters are overwhelmingly foreign owned or joint ventures. The unconditional association between foreign ownership and marginal cost is some convex combination of the coefficients on processing trader

Parameter	**Mean**	**Std**
Price elasticity-Western hemisphere	-4.697**	0.991
Price elasticity-Former Soviet Republics	-4.396**	0.922
Price elasticity-Rest of Europe	-4.440**	0.991
Price elasticity-JPN/KOR/AUS/NZL	-4.261**	0.980
Price elasticity-Rest of Asia	-4.326**	0.946
Price elasticity-Africa	-4.718**	0.945
Price elasticity-product 1	benchmark	
Price elasticity-product 2	0.203	0.427
Price elasticity-product 3	1.025**	0.375
Price elasticity-product 4	0.627*	0.303
FMA-Western hemisphere	0.583	0.399
FMA-Former Soviet Republics	1.173*	0.462
FMA-Rest of Europe	1.209**	0.393
FMA-JPN/KOR/AUS/NZL	0.495	0.625
FMA-Rest of Asia	0.433	0.394
FMA-Africa	1.024	0.409
Linear decay rate	-0.055	0.094
SOE	3.327**	0.822
JV	5.348**	1.120
FIE	2.081**	0.239

Table 1: Parameters in Demand Equation

Notes: Aggregate demand coefficients for sector, destination, and period are not reported. ** and * denote statistically significant at the 5% and 10% levels, respectively.

and foreign ownership. Somewhat disappointingly, the coefficient on local wage is not statistically significant.

5.3 Parameters for the Permanent and Transitory Shocks

There are four random variables in the demand and pricing equations. 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. 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.

Parameter	Mean	Std
SOE	0.904**	0.119
JV	1.159**	0.200
FIE	0.236	0.169
processing status	-0.354**	0.083
trader	-0.412**	0.115
local wage	-0.067	0.195
Destination fixed effects	not reported	
Sector fixed effects	not reported	
Period fixed effects	not reported	

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 5% level.

There are in total 8 parameters. We report the estimation results in Table 3. We note that the standard deviation for the permanent demand shock (1.19) is somewhat greater than that for the permanent productivity shock (0.94). This pattern is consistent with the findings reported in Roberts et al. (2012) for Taiwanese footwear exporters. A relatively big dispersion in the persistent demand shock across firms may reflect dispersion in product quality across firms or dispersion in consumer taste over varieties.

5.4 Parameters for the Export Cost

Fixed entry costs are assumed to be a random variable that follows a normal distribution with sector and region specific parameters. In order to put a dollar value to the estimates, we have to make an assumption about the discount factor (because the entry costs will be inferred from expected life-time profits of the firms. Assuming that the discount factor $\beta = 0.96$, the second column of Table 4 reports the estimates of the mean by sector and region, together with associated standard errors. The third column reports the estimates of the standard deviation by sector and region, together with the standard errors. As we can see, across all products and regions, the mean export costs range from \$0.32 million to \$0.64 million.

5.5 Discovery Cost Parameters

The discovery cost is assumed to be a constant that may differ by sector and region. Assuming that the discount factor $\beta = 0.96$, the discovery costs are

Permanent Shocks		
	Mean	Std
Productivity	2.541	0.944**
	(0.028)	(0.018)
Demand	2.223**	1.187**
	(0.017)	(0.023)
corr	-3.579**	
	(0.014)	
Transitory Shocks		
u		0.266**
v		1.717**
corr		-0.220
		(0.134)

Table 3: Parameters for the Random Variables

Notes: ** denotes statistically significant at the 5% level. Standard errors are reported in brackets.

reported in Table 5. As we can see, the discovery cost ranges from 0.54 million to 1.21 million US dollars.

It is important to note that while we have to make a specific assumption about the discount factor in order to place a dollar value on the estimates of the fixed entry costs and discovery costs, our subsequent discussion on the probability of missing pioneers is independent of the specific value of the discount factor. A change in the value of the discount factor would change all firms' expected life-time profits, entry costs, and discovery costs proportionately. As a result, firms' decisions on whether to become an export pioneer or whether to export in a mature market are independent of the specific value of the discount factor.

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 the action of the first exporter is a public good existence of a public good - it reduces the total entry cost by all follower firms. In this sense, we confirm the findings in Freund and Pierola (2010) and Artopoulos, Friel, and Hallak (2013) that positive spillover exists. As we show below, however, the existence of public good does not automatically lead to market failure.

	Mean (in thousands dollars)	**Standard deviations**
Sector 1		
Export cost-Western hemisphere	619.7**	289.2**
	(5.8)	(143.9)
Export cost-Former Soviet Republics	555.3**	211.3*
	(8.1)	(128.2)
Export cost-Rest of Europe	637.8**	328.5*
	(5.7)	(179.1)
Export cost-JPN/KOR/AUS/NZL	553.3**	222.6
	(7.9)	(75.5)
Export cost-Rest of Asia	626.0**	295.6
	(4.7)	(135.6)
Export cost-Africa	614.3**	239.4
	(6.4)	(58.1)
Sector 2		
Export cost-Western hemisphere	473.1**	202.3*
	(10.4)	(116.9)
Export cost-Former Soviet Republics	459.9**	92.3**
	(18.2)	(15.8)
Export cost-Rest of Europe	450.8**	241.9**
	(8.8)	(45.0)
Export cost-JPN/KOR/AUS/NZL	377.6**	156.5**
	(10.6)	(37.3)
Export cost-Rest of Asia	506.0**	211.6**
	(9.2)	(40.0)
Export cost-Africa	470.9**	183.7
	(10.7)	(126.3)
Sector 3		
Export cost-Western hemisphere	411.2**	168.1**
	(7.6)	(78.2)
Export cost-Former Soviet Republics	318.9**	148.6**
	(7.1)	(37.0)
Export cost-Rest of Europe	412.2**	164.4
	(7.9)	(110.8)
Export cost-JPN/KOR/AUS/NZL	358.5**	78.2**
	(20.5)	(4.5)
Export cost-Rest of Asia	416.6**	158.7**
	(7.2)	(60.3)
Export cost-Africa	416.2**	155.1**
	(8.1)	(54.5)
Sector 4		
Export cost-Western hemisphere	541.1**	236.8**
	(7.1)	(109.8)
Export cost-Former Soviet Republics	451.6**	192.2**
	(7.9)	(88.9)
Export cost-Rest of Europe	609.8**	320.0**
	(7.2)	(72.7)
Export cost-JPN/KOR/AUS/NZL	491.7**	201.9**
	(9.1)	(79.5)
Export cost-Rest of Asia	590.4**	259.3**
	(6.3)	(95.2)
Export cost-Africa	486.4**	216.9*
	(6.3)	(114.0)

Table 4: Parameters for the Export Cost

Notes: Standard errors of the point estimates are reported in brackets. ** and * denote statistically significant at the 5% and 10% levels, respectively.

	Estimates (in thousands dollars)	**Standard deviations**
Sector 1		
Discovery cost-Western hemisphere	893.5**	9.7
Discovery cost-Former Soviet Republics	876.4**	13.9
Discovery cost-Rest of Europe	1,212.1**	8.1
Discovery cost-JPN/KOR/AUS/NZL	892.9**	22.1
Discovery cost-Rest of Asia	827.6**	7.6
Discovery cost-Africa	833.1**	7.9
Sector 2		
Discovery cost-Western hemisphere	926.5**	18.7
Discovery cost-Former Soviet Republics	1,020.7**	117.7
Discovery cost-Rest of Europe	1,153.7**	13.2
Discovery cost-JPN/KOR/AUS/NZL	813.0**	28.9
Discovery cost-Rest of Asia	796.5**	14.0
Discovery cost-Africa	917.9**	14.9
Sector 3		
Discovery cost-Western hemisphere	1,082.1**	10.7
Discovery cost-Former Soviet Republics	1,060.1**	15.0
Discovery cost-Rest of Europe	1,134.8**	14.5
Discovery cost-JPN/KOR/AUS/NZL	987.3**	52.8
Discovery cost-Rest of Asia	1,064.8**	10.3
Discovery cost-Africa	1,037.0**	8.7
Sector 4		
Discovery cost-Western hemisphere	588.2**	11.0
Discovery cost-Former Soviet Republics	555.7**	16.6
Discovery cost-Rest of Europe	999.7**	9.5
Discovery cost-JPN/KOR/AUS/NZL	639.4**	25.3
Discovery cost-Rest of Asia	667.1**	9.9
Discovery cost-Africa	543.9**	9.6

Table 5: Discovery Costs

Notes: ** denotes statistically significant at the 5% level.

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, 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 Probability of Market Failures

To start with, we note an important role played by the number of potential exporters (which is a measure of the size of a country-sector). Even without doing any 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 there is only one firm, it is clear that there is no market failure because the social planner's and the individual firm's optimization problems coincide (hence $\eta_k^d = 0$). At the other extreme, if the number of firms is infinite and the distributions for the permanent productivity and the demand shock are not bounded on the right, which are satisfied if productivity distribution or demand shock distribution is normal, log normal, or Pareto, then some firm is bound to get a productivity draw so high (or a demand draw so favorable) that it wants to be a pioneer anyway even if its action benefits other firms. Therefore, the probability of "missing pioneers" is likely to be higher only for some intermediate values of the number of potential exporters. 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 now use estimated structural parameters and simulations to answer these questions.[10]

[10] We explain how we solve the planner problem in the appendix B.

For any particular value for the number of potential exporters in E_0, we randomly draw permanent productivity and demand shocks and the fixed entry costs from the estimated distributions of these variables. Based on the realization of the shock, we can determine if the missing pioneer problem arises or not. (Recall that the firms make export decisions before the transitory shocks to productivity and demand are realized.) For 1000 randowm draws, we can compute the probability of market failure η_k^d for that particular number of potential exporters E_0. We trace out the probability of missing pioneers in Figure 2 by varying E_0 from 1 to 200.

In the top graph of Figure 2, we plot three lines. A broken red line traces out the probability that no firm wants to be a pioneer as a function of the number of potential exporters. This is a declining function because, as the number of firms increases, it becomes increasingly likely that some firm will get a very lucky draw from either the productivity distribution or the demand shock distribution or both so that it would want to be a pioneer. A broken blue line denotes the probability that the social planner prefers to have a pioneer. This probability rises with the number of firms because the sum of the expected profits across firms from successfully exporting to a new destination - something that the social planner cares about - tends to rise with the number of exporters. Finally, a solid blue line represents the probability of missing pioneers (i.e., when the social planner wishes to have an export pioneer yet no individual firm wants to be one). Logically, the probability of "missing pioneers" should be lower than the smaller of the first two probabilities. Because "no firm wants to be a pioneer" and "the planner wants a pioneer" are not independent events, the probability of "missing pioneers" can be lower than the lower envelope of either the broken red line or the broken blue line.

Interestingly, we find that one cannot make a blanket statement about this type of market failure. The probability of missing pioneers depends on the size of a country-sector (or the number of potential exporters to be precise). This type of market failure can be a serious problem for a small country-sector, with a peak probability of missing pioneers around 70% when the number of potential exporters is about 10. On the other hand, since the mean and median numbers of actual exporters are 394 and 295 for a 6-digit product in our Chinese example, and the potential number of exporters is likely to be greater than the actual number, the probability of missing pioneers is close to zero for a large country. In Table 6, Column 2 reports the probability of missing pioneers as a function of the number of potential exporters that corresponds to Figure 2.

Number of entrants	Prob of missing pioneers	Prob of premature pioneers
5	0.31	0.01
10	0.71	0.02
15	0.63	0.00
20	0.56	0.00
25	0.48	0.00
30	0.41	0.00
35	0.37	0.00
40	0.34	0.00
45	0.31	0.00
50	0.27	0.00
55	0.24	0.00
60	0.20	0.00
65	0.17	0.00
70	0.14	0.00
75	0.12	0.00
100	0.05	0.00
150	0.01	0.00
200	0.00	0.00
250	0.00	0.00
300	0.00	0.00

Table 6: Probability of Market Failure

As we can see, when the number of potential exporters is greater than 45, the probability of missing pioneers is 31% or smaller. When the potential number of exporters in a country-sector is 100 or more, the probability of this type of market failure is 5% or less.

Conceptually, we can have a second type of market failure - the problem of "premature pioneers" - when a firm decides to be a pioneer but the social planner prefers that all firms wait for at least one more period. We report the probability of "premature pioneers" as a function of the number of potential exporters in Column 3 of Table 6, and plot the relationship in a solid blue line in the lower graph of Figure 2 (together with the probability that some firm wants to be a pioneer in a broken red line, and the probability that the social planner wants no pioneers in a broken blue line). The probability of "premature pioneers" as a function of the number of exporters also has an inverse-V shape. However, the most striking conclusion is that in our baseline estimation, this second type of market failure is a low-probability event for any number of potential exporters.

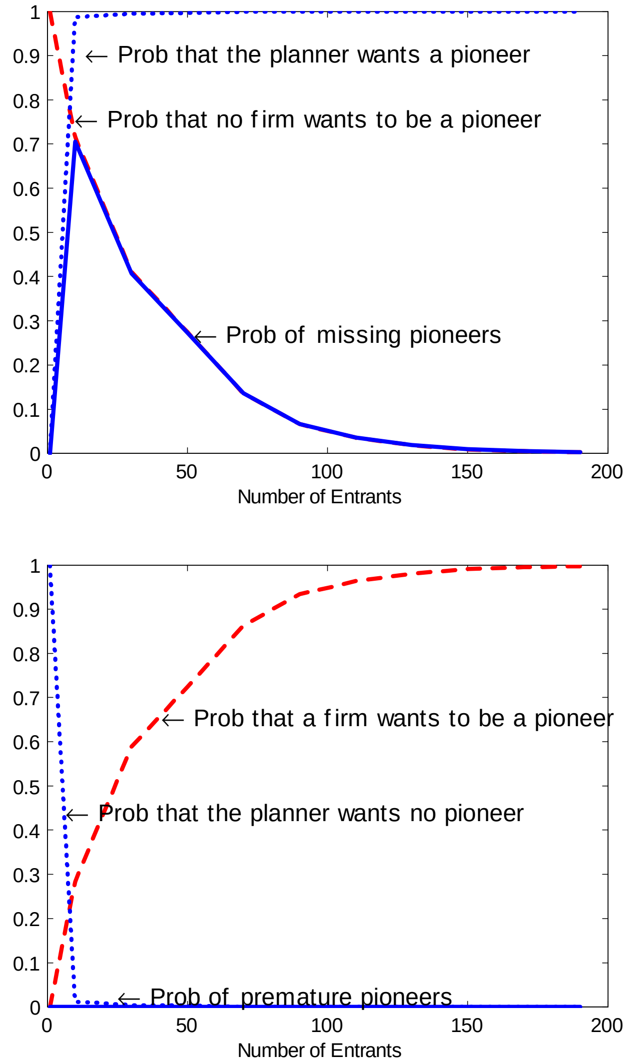

Figure 2: Probability of market failures

7 Extensions and Robustness Checks

We now explore a number of extensions, starting with an exploration of the roles of first mover advantage and the dispersions of productivity and demand shocks.

7.1 Shutting Down FMA

To develop some idea about the importance of first mover advantage in our inference, we attempt to artificially shut down the FMA in this section. In the baseline case, we assume that a pioneer firm receives a boost in its export sales at the beginning which then gradually decays to 0. We use the point estimates of all parameters in simulating the proability of market failure.

As an alternative simulation, we impose in the demand equation (2) that $\theta = \lambda = 0$ (but otherwise use the same set of estimated parameters as in the baseline simulation). Hence the pioneer firm no longer enjoys any first mover advantage. Our conjecture is that, without FMA, firms should be less inclined to want to be a pioneer, and correspondingly, the probability of missing pioneers should rise.

We plot the probability of missing pioneers under the new simulation in the upper left graph of Figure 3. Indeed, the probability of missing pioneers now rises dramatically, with a peak in excess of 95% when the number of potential exporters is around 15. More importantly, it has become a substantially more serious problem even for a large country-sector. We plot the probability of premature pioneers in the upper right graph of Figure 3. Perhaps not surprisingly, this probability stays low when we shut down FMA.

If the true data generating process is known to have no FMA, we can also directly impose this restriction ($\theta = \lambda = 0$) and re-estimate the model. In this case, other parameters could also differ from those in the baseline estimation. Based on the re-estimated model, we re-do the simulations and present the corresponding probabilities of missing pioneers and premature pioneers, respectively, in the bottom two graphs of Figure 3. We can see that the probability of missing pioneers is much higher than the baseline case but slightly lower than if we pretend that other parameters are not affected by shutting down FMA. The probability of premature pioneers still stays low.

To summarize, taking into account the possibility of a first mover advantage turns out to matter a lot in assessing the probability of missing pioneers.

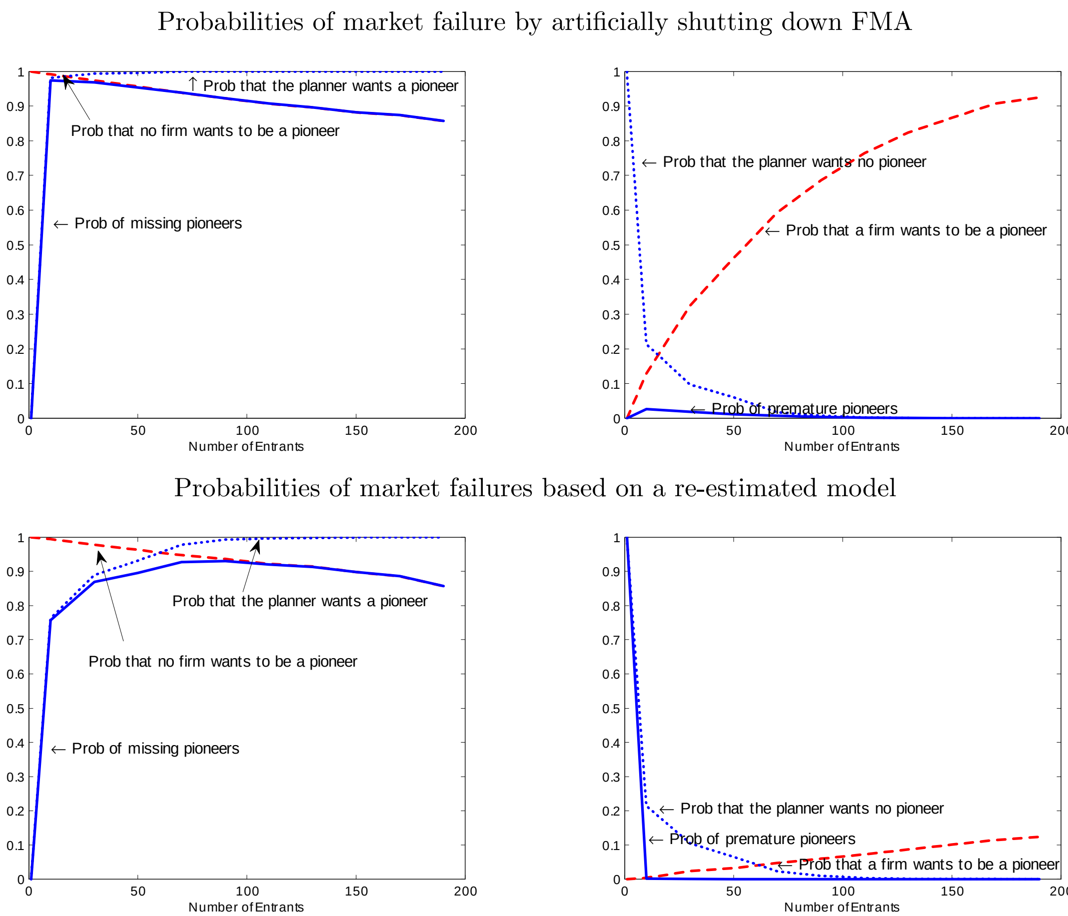

Figure 3: Shutting down FMA

7.2 Dispersions in productivity and demand

We now 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 pioneers 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 \$200 but the cost of discovery is \$300. 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 \$20,000 (=100x200), far exceeding the discovery cost. Hence, we have a market failure. However, if the firms are heterogenous, and the expected profits vary from \$0 to \$600 even though the mean expected profit is still \$200, then the most productive firm would prefer to be a pioneer and there will be no market failure.

We can examine the relevance of this point in our context. Specifically, we will vary the size of the dispersions of the permanent demand and productivity shocks while keeping all other parameters fixed at the estimated values. Of course, we can also vary the size of the discovery cost while keeping the dispersions constant.

In the left figure 4, we plot the probability of missing pioneers corresponding to three different values of dispersions in permanent productivity and demand shocks across firms ($\sigma =$ the baseline estimate, 100 times the baseline estimates, and 0.01 times the baseline estimates, 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 particular, when both the productivity and demand shocks are assumed to have a much smaller standard deviation (by 99%) than what are observed in the data, the probability of missing pioneers can peak at around 80%. However, even in that case, when the number of potential exporters exceeds 45, the probability of missing pioneers again becomes small.

In the right graph of figure 4, we increase and reduce the size of discovery cost of all sectors and destinations (100 times the baseline estimates, and 0.01 times the baseline estimates, respectively), while keeping all other parameters

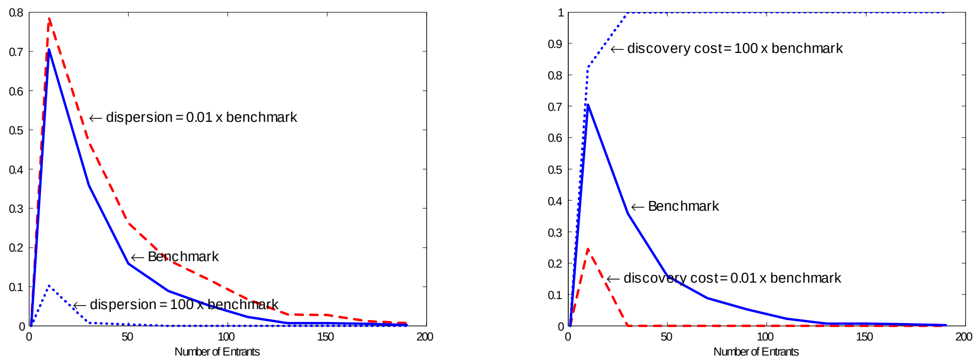

Figure 4: Varying dispersions and discovery cost

at the values of their baseline estimates. When the discovery cost increases, the probability of missing pioneers increases since firms are more reluctant to pay the cost. Similarly, when the discovery cost decreases, the probability of missing pioneers decreases.

We conclude from this exercise that the probability of missing pioneers depends on the dispersion of the productivity and demand shocks, especially when the size of a country-sector is in an intermediate range. To put it differently, the homogenous firm assumption in the models of Hoff (1997) and Hausmann and Rodrik (2003) may not be an innocuous assumption. Similarly, the size of discovery costs also matters. Our conclusion on the probability of missing pioneers is not pre-determined by our empirical specification. Rather, estimated sizes of the dispersions in productivity and demand shocks and of the discovery costs collectively determine whether missing pioneers are a high or low probability event.

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-

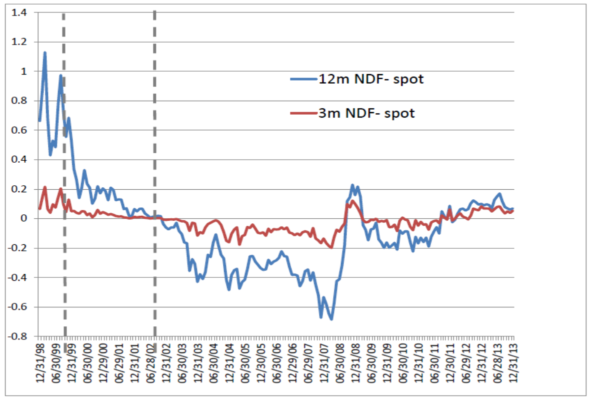

Figure 5: RMB/US dollar Forward Rate (1998-2013)

2002, the period in which export pioneering activities take place in our sample. In Figure 5, we plot the forward Chinese exchange rate (units of Chinese 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 somewhat 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 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 products 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 and McCulloch, 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.[11] As a robustness check, we exclude this sector from our data and re-estimate the model. This does not alter our conclusions.

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 market failure. On the other hand, costs of dealing with corruption and regulatory barriers could be lower in more developed economies, implying a lower probability of market failure. To formally link the size of the discovery cost to a country's size, income level, and other characteristics, and allow them to vary by sector and region, would add many more parameters. This would increase the computational time substantially. As a short cut, 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

[11] 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.

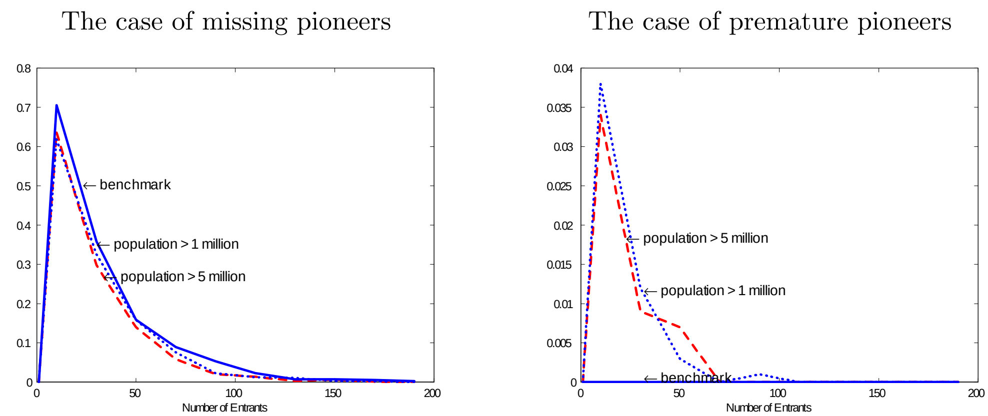

Figure 6: Probability of Missing Pioneers, Excluding Smaller Countries

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 two reduced samples, and report the results in Figure 6. The new results turn out to be similar to the baseline case. In particular, we find that missing pioneers (the left graph) is a low-probability event for large country-sectors but can be a more serious problem for smaller country-sectors.

The probability of premature pioneers is plotted in the right graph of Figure 6. Note the scale of the vertical axis which peaks at 0.04. While the probability of premature pioneers increases when we exclude smaller or poorer countries, it stays low in absolute values.

7.5 Intermediary Firms

Intermediary firms are firms that specialize in exports and imports, and may not be producers themselves. They play an important part in facilitating trade (Ahn, Khandelwal, and Wei, 2011). It is natural to ask whether their presence affects the probability of market failure. Data show that around 20% of Chinese export transactions or 2% of the export value in sectors HS8525-8528 during 2000-2006 were carried out by intermediaries.

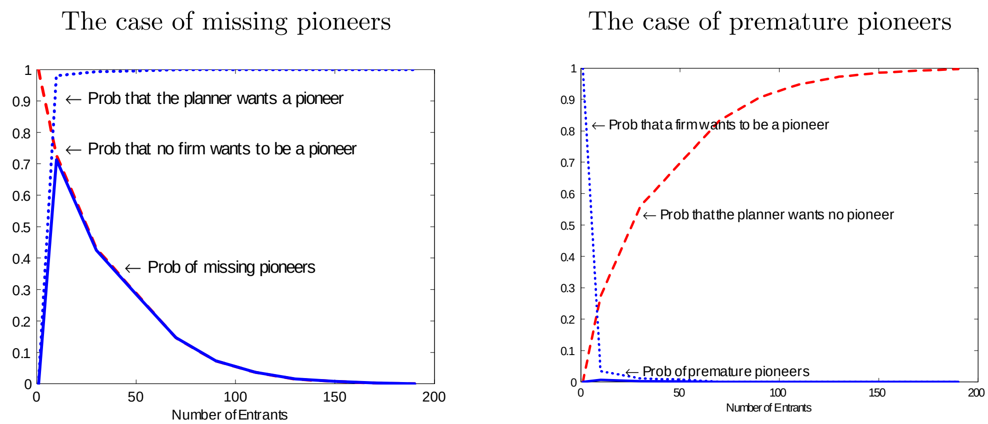

Figure 7: Excluding intermediary firms

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. Instead, we elect to 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 7. As we can see, without giving credit to intermediary firms in conquering new markets, the probability of missing pioneers tends to be slightly higher than the baseline case although the quantitative difference between the two cases seems small.

7.6 Additional Knowledge Spillover

In the benchmark case, we assume followers can only benefit from a pioneer firm's action in the same product-destination pair. In this subsection, we broaden the set of channels a firm can benefit from the actions of other firms or even their own prior actions. In particular, we allow four additional channels, to be captured by four additional parameters that are related to observable firm characteristics $\vec{w}_i(t)$ in equation (4).[12] The first is a firm's own export value of different products to the same destination in period $t-1$, which captures

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

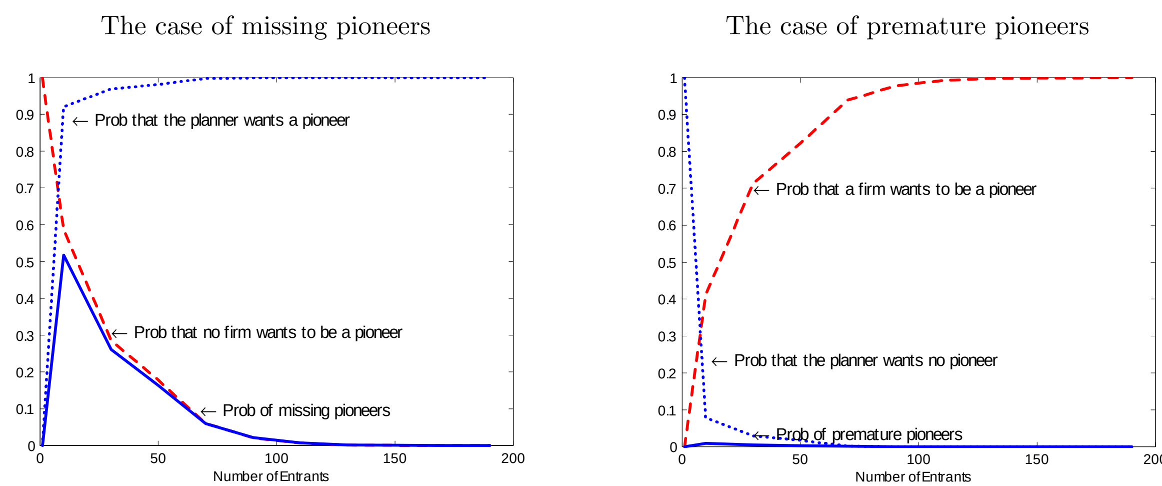

Figure 8: Additional Learning Channels

knowledge spillover from one's own exports to the same destination. Albornoz et al. (2012) explore this idea. The second is a firm's own export value of the same products to different destinations in period $t-1$, which captures knowledge spillover from exports of the same products regardless of destination.

Besides benefiting from the firm's own export experience, we also explore knowledge spillovers from other firms. Fernandes 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 $t-1$.[13] 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 variables Ω_i^d now includes these four additional variables.[14]

The new specification allows firms to be multi-product producers and indeed makes use of the observations on multi-product exports from the same firms. Using the expanded set of structural parameters, we re-compute the probabilities

[13] Fernandes and Tang (2012) also examine whether knowledge spillover dissipates with physical evidence 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.

[14] We keep the demand equation (3) the same and change the pricing equation (5) by augmenting $\vec{w}_i(t)$. Hence $\vec{w}_i(t)$ includes not only the firm's ownership and local wage but also four new variables that captures learning from own experience and learning from other firms. Then the export decision and pioneer decision rules are also changed since state variables Ω_i^d are augmented too.

of market failures and present it in Figure 8. Compared to the baseline case, we find that the probability of missing pioneers has now dramatically declined for smaller country sectors, with the peak probability now around 50% (as opposed to 70% in the baseline case). On the other hand, the probability of premature pioneers has increased a bit, although still low in terms of the absolute value. 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.

7.7 Separating first-time entry costs from generic entry costs

In our baseline setup, an exporting firm faces two fixed costs of entry: a discovery cost that is paid for only by a pioneer, and a generic fixed entry cost that needs to be paid for by every exporting firm. It is possible that there is a third type of entry cost, one that is paid for by an exporter the first time it enters a new market whether or not it is a pioneer. In other words, if a market is new to a firm even if it is not new to the exporting country, the firm may have to pay a cost on top of the generic entry cost. Without considering this third type of cost, we may have over-estimated the discovery cost.

In this section, we extend our benchmark model to allow for this possibility. We assume this third type of entry cost, denoted by F, is a constant. Assuming the discount factor is 0.96, the first-time entry cost is reported in Table 7. The first-time entry cost is about 530 thousands dollars on average. Tables 8 and 9 report the export costs and the discovery costs in the new model, respectively. The export costs do not change too much while the discovery costs become somewhat smaller. Figure 9 plots the probaility of missing pioneers in this case. As we can see, the peak probability of missing pioneers (about 50%) is lower than the corresponding number in the baseline case. Otherwise, this generalization does not materially alter our inference. In particular, the probability of missing pioneers is low for large country-sectors though it can be higher for smaller ones. Interestingly, the probability of premature pioneers is somewhat higher than in the baseline case, though it is still low in an absolute sense.

	Estimates (in thousands dollars)	**Standard deviations**
Sector 1		
First time cost-Western hemisphere	231.1**	0.6
First time cost-Former Soviet Republics	365.8**	0.8
First time cost-Rest of Europe	208.9**	0.6
First time cost-JPN/KOR/AUS/NZL	342.8**	1.4
First time cost-Rest of Asia	365.8**	0.5
First time cost-Africa	483.2**	0.7
Sector 2		
First time cost-Western hemisphere	462.2**	1.2
First time cost-Former Soviet Republics	596.9**	1.4
First time cost-Rest of Europe	440.0**	1.2
First time cost-JPN/KOR/AUS/NZL	573.9**	2.0
First time cost-Rest of Asia	596.9**	1.1
First time cost-Africa	714.3**	1.4
Sector 3		
First time cost-Western hemisphere	596.9**	1.4
First time cost-Former Soviet Republics	731.6**	1.6
First time cost-Rest of Europe	574.7**	1.4
First time cost-JPN/KOR/AUS/NZL	708.6**	2.2
First time cost-Rest of Asia	731.6**	1.3
First time cost-Africa	849.0**	1.5
Sector 4		
First time cost-Western hemisphere	440.0**	1.2
First time cost-Former Soviet Republics	574.7**	1.4
First time cost-Rest of Europe	417.8**	1.1
First time cost-JPN/KOR/AUS/NZL	551.7**	2.0
First time cost-Rest of Asia	574.7**	1.1
First time cost-Africa	692.1**	1.3

Table 7: First Entry Cost for First Time Exporter to a Market

Note: ** denotes statistically significant at the 5% level.

	Mean (in thousands dollars)	**Standard deviations**
Sector 1		
Export cost-Western hemisphere	643.37**	52.5
	(15.23)	(45.2)
Export cost-Former Soviet Republics	525.35**	101.2
	(14.01)	(129.6)
Export cost-Rest of Europe	644.33**	127.1
	(8.74)	(148.4)
Export cost-JPN/KOR/AUS/NZL	548.58**	34.1
	(28.63)	(43.1)
Export cost-Rest of Asia	708.27**	26.9
	(7.18)	(32.6)
Export cost-Africa	668.45**	18.2
	(10.81)	(30.4)
Sector 2		
Export cost-Western hemisphere	453.54**	40.6
	(15.76)	(61.5)
Export cost-Former Soviet Republics	404.74**	80.1
	(15.80)	(105.5)
Export cost-Rest of Europe	461.05**	49.6
	(15.80)	(107.4)
Export cost-JPN/KOR/AUS/NZL	383.54**	33.0
	(15.72)	(159.4)
Export cost-Rest of Asia	467.49**	69.2
	(13.60)	(71.9)
Export cost-Africa	431.24**	195.5*
	(13.35)	(67.8)
Sector 3		
Export cost-Western hemisphere	390.34**	229.3
	(9.06)	(79.4)
Export cost-Former Soviet Republics	337.65**	59.7
	(17.18)	(41.2)
Export cost-Rest of Europe	402.63**	67.9
	(12.78)	(115.3)
Export cost-JPN/KOR/AUS/NZL	342.49**	75.6
	(24.60)	(33.2)
Export cost-Rest of Asia	410.22**	111.4
	(8.27)	(79.9)
Export cost-Africa	399.88**	80.3
	(9.09)	(101.3)
Sector 4		
Export cost-Western hemisphere	531.95**	90.3
	(10.06)	(135.2)
Export cost-Former Soviet Republics	443.07**	255.9
	(13.31)	(86.5)
Export cost-Rest of Europe	587.13**	96.5
	(11.35)	(182.0)
Export cost-JPN/KOR/AUS/NZL	482.48**	28.5
	(19.91)	(40.4)
Export cost-Rest of Asia	602.34**	153.6
	(11.05)	(161.4)
Export cost-Africa	487.6**	107.5
	(9.55)	(122.4)

Table 8: Parameters for the Export Cost

Notes: Standard errors of the point estimates are reported in brackets. ** and * denote statistically significant at the 5% and 10% levels, respectively.

	Estimates (in thousands dollars)	**Standard deviations**
Sector 1		
Discovery cost-Western hemisphere	182.8**	10.0
Discovery cost-Former Soviet Republics	346.0**	13.2
Discovery cost-Rest of Europe	187.6**	9.0
Discovery cost-JPN/KOR/AUS/NZL	331.8**	22.7
Discovery cost-Rest of Asia	317.2**	7.6
Discovery cost-Africa	425.7**	8.0
Sector 2		
Discovery cost-Western hemisphere	229.9**	21.4
Discovery cost-Former Soviet Republics	125.4**	29.4
Discovery cost-Rest of Europe	352.2**	15.0
Discovery cost-JPN/KOR/AUS/NZL	280.2**	26.5
Discovery cost-Rest of Asia	335.6**	13.9
Discovery cost-Africa	122.4**	16.1
Sector 3		
Discovery cost-Western hemisphere	268.5**	10.3
Discovery cost-Former Soviet Republics	231.4**	15.3
Discovery cost-Rest of Europe	257.6**	14.0
Discovery cost-JPN/KOR/AUS/NZL	157.9**	45.8
Discovery cost-Rest of Asia	276.4**	10.2
Discovery cost-Africa	122.5**	8.8
Sector 4		
Discovery cost-Western hemisphere	384.7**	11.0
Discovery cost-Former Soviet Republics	481.5**	15.6
Discovery cost-Rest of Europe	125.5**	10.3
Discovery cost-JPN/KOR/AUS/NZL	267.9**	24.1
Discovery cost-Rest of Asia	606.5**	9.8
Discovery cost-Africa	414.3**	9.5

Table 9: Discovery Costs

Note: ** denotes statistically significant at the 5% level.

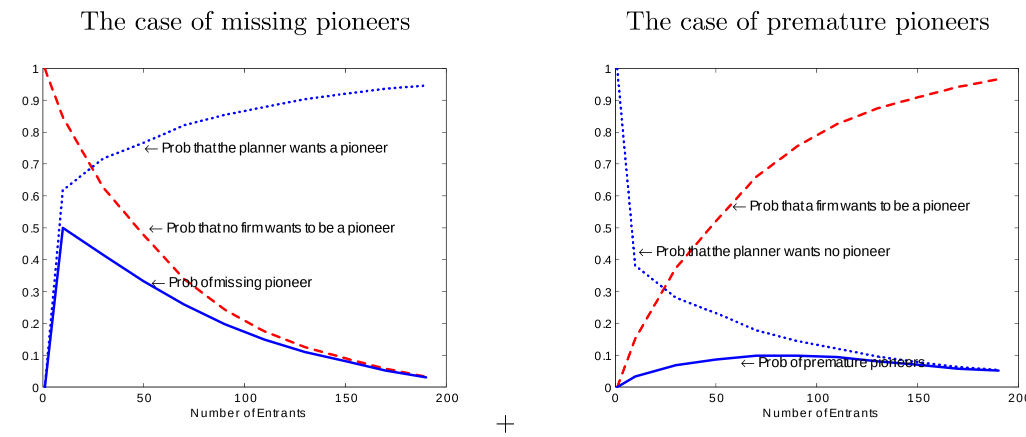

Figure 9: Probability of Missing Pioneers, Including First Export Cost

7.8 Market Failure in Exporting Brand New Products

The analysis so far has focused on missing pioneers 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" in this type of activity in the manufacturing sector.

First, for a given country j, we estimate the set of manufacturing goods in which country j may have potential comparative advantage in 2002 based on the export bundles of both country j and other similar countries. We define all countries whose per capita incomes are within (-20%, +20%) of country j in 2002 as similar countries. Second, we compute the fraction of such goods that country j did not export in 2002.

For example, to define a set of countries similar to China in 2002, we look at all countries whose per capita income is within (-20%, +20%) of the Chinese level ($1135 in 2002). There are 12 such countries: 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 assume each of its HS 6-digit manufacturing export products as a potential comparative advantage product for China. Note that the 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 4011 products (out of a total of 5110 manufacturing products). This is a set of products for which 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 101 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=4226.

In this case, the probability of failure in exporting brand new products that China could be exporting is M/(R+M) = 101/4226 = 2.4%. Some of the products in M may be ones for which China has no genuine comparative advantage. For example, some "similar countries" export processed gold products because they happen to have an abundant gold reserve but gold is scarce in China. So R+M may overstate the set of products in which China has comparative advantage. In other words, even after erring on the side of exaggerating what China could be exporting, the probability of failing to export some brand new products is fairly low.

One may conjecture that the country size is important here. While the probability of failure to export some brand new products is small for China, it could be greater for smaller countries. We do the same exercise for additional 194 countries in the Comtrade database (for which we have both GDP and population data). In Table 10, we regress the fraction of products that a country might have a comparative advantage but fails to export - potential failure in exporting brand new products - on log GDP, log population, and log per capita GDP, both individually and collectively. Note that because the three variables are perfectly collinear, we can have at most two of the variables in a given regression. We find that the potential failure in exporting brand new products tends to decline with country size, proxied by either log GDP or log population. The potential failure appears more serious for small economies but not so for large economies. Furthermore, log GDP seems to be a better predictor than log population for the likelihood of potential failure. This is sensible as the number of potential exporters in an economy is likely linked to both population and

	(1)	(2)	(3)	(4)	(5)
Log (population)	-0.087**			-0.111**	0.016
	(0.010)			(0.008)	(0.011)
Log (GDP)		-0.116**	-0.111**		-0.127**
		(0.007)	(0.008)		(0.010)
Log (pc GDP)			-0.016	-0.127**	
			(0.011)	(0.010)	
Observations	195	195	195	195	195
R-squared	0.286	0.596	0.6	0.601	0.6

Table 10: Comparative Advantage and Actual Exports

Notes: ** denotes statistically significant at the 5% level. An intercept is included in all regressions but not reported.

income per capita.

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 the action of the first exporter has public good features and then often jump to the condition that market failure exists and some government intervention is needed. In comparison, we stress that the public goods feature of the first exporter's action is only necessary but not sufficient for the existence of market failure. For market failure to occur, one has to evaluate whether two inequalities specified in this paper hold simultaneously. No existing paper in the literature has adopted this approach.

We propose a structural framework to estimate the relevant parameters. We provide supportive evidence that the action of the first exporter has public good features. Nonetheless, we find that the problem of "missing pioneers" is a low probability event for large or medium country sectors. This conclusion appears robust in a number of extensions and checks we have examined.

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 our calibrations, if we artificially shut down first mover advantage, we would have concluded (incorrectly) that the probability of missing pioneers is high even for large country-sectors.

For international trade, 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 develop more insight about how country characteristics may affect probabilities of market failure.

For public finance or microeconomics, a major claim of the paper is that public goods or externality does not necessarily lead to market failure or a case for intervention, if there is a fixed cost component in the cost of public goods provision or in the investment needed for the activities that generate the externality. One should be able to find applications of this point outside the field of international trade. We leave such exercises to future research.

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9 Online Appendix A: Estimation Procedure (not for publication)

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, a pricing equation, an export decision rule, and a pioneer decision rule. 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 have two steps. First, we estimate ω_i, ξ_i^d, the parameters in the demand equation $\left(\alpha_k^d, \lambda, \theta^d\right)$ and parameters in the pricing equation $\left(\gamma^d, \gamma_k, \gamma(t), \kappa_w\right)$ using data on an individual firm's prices and quantities.

Second, conditional on the set of parameters from step 1, we estimate other parameters via the MLE. Denote the set of all parameters as Θ. Then the likelihood of entry/exit can be written as

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

where G is the cumulative distribution function of a normal distribution.

10 Online Appendix B: Solving the Planner Problem (not for publication)

Consider first the problem of a follower firm. In equations (9), (10), and (11), we define $\ln a_i$ (time invariant part), $\ln r_i\left(t\right)$ (time variant part), and $\ln b_i\left(t\right)$ (FMA) in the firm profit function. By definition, the follower firm does not have FMA, so $\ln b_i\left(t\right)=0$. The expected static profit is

$$\ln \pi_i\left(t\right) = \ln a_i + \ln r_i\left(t\right) \tag{23}$$

Let us denote the distribution of individual firm state variables as $f\left(t\right)$. Given the realization of the static profit in period 0, if the planner wants to choose one firm to become the pioneer, the expected value is

$$J^E\left(f\left(0\right)\right) = \max_i \left\{V_i^P + \beta\sum_{j\neq i} EV_i^F\right\} \tag{24}$$

That is, the planner chooses the optimal firm i to become the pioneer firm and it gets the value V_i^P, while other firms will become follower firms and they wait one period and get the expected value of follower firms.

Then the planner's problem can be described by

$$J\left(f\right) = \max\left\{J^E, \beta E\left[J\left(f'\right)|f\right]\right\} \tag{25}$$

The above equation has two parts. The first part is the value of choosing one firm to become the pioneer firm. The seconed part is the expected value for the planner to wait one more period. Given that all state variables of individual firms are Markovian processes, it is enough to infer distribution next period f' from the distribution of current state variables f.

Generally, the space of f is very large (we need to track all firms' individual states). To solve the planner's problem, we approximate the distribution of individual state variables by several moments (mean, standard deviation, etc.). We adopt the following procedure: for a given destination,

(1) Fix the number of potential entrants N. We do so by randomly drawing N firms in a 4-digit sector. We know their a_i. They are time invariant.

(2) For those N firms, compute the mean and standard deviation of $\ln r_i(t)$ for every period t. Then approximate the transition of moments of $\ln r_i(t)$ by Markovian processes. We then can estimate the transition matrix.

(3) Simulate one realization of $r_i(0)$ and export cost $\phi_i(0)$ and then compute the firm value $V_i^P(0)$ and $E_0 V_i^F$ for each potential firm.

(4) Compute J^E given the realization of the individual firm state variables.

(5) Solve the planner problem $J(f)$ from the Bellman equation (25).

(6) For each simulation in step 3, compute the optimal policy of the planner and then the probability of market failure.

11 Online Appendix C: Chinese data - Additional Details (not for publication)

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.

Our core sample is the Chinese exports of 21 electronics products spanning four 4-digit sectors (HS8525-8528) in HS Chapter 85 (electrical machinery and 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 to which China did not export during 1996-1999 but did during 2000-2002. 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

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 (# products 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]

Appendix Table 1: Sample Distribution of Sector HS8525-8528

total) during 2000-2002 and trace the dynamics of both the pioneers and all followers during 2000-2006.

Our 21 products come from four consumer electronics sectors from Chapter HS85 (electrical machinery and equipment). They are: (1) four products from HS8525, transmission apparatus for radiotelephony, TV cameras, and cordless telephones, (2) three products from HS8526, radar apparatus, radio navigation aid, and remote control apparatus, (3) nine products from HS8527, reception apparatus for radiotelephony, etc., and (4) five products from HS8528, television receivers, etc. Key features of these four sectors are reported in the first panel of Table 11.

Note that by the end of 1999, these four sectors had entered different numbers of markets: HS8526 was relatively under-explored by the end of 1999 whereas HS8527 was relatively more explored. The distribution of mature markets as of the 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 Appendix Table 1.

A firm is called a pioneer if it is the very first Chinese exporter of a particular product to a particular destination. All subsequent entrants (for the same product-destination pair) are 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

		Total number of firms in a region					
HS code	Number of exporters	Western hemisphere	FSR	Europe	JPN/KOR AUS/NZL	Rest of Asia	Africa
852713	1019	394	28	252	145	806	123
852732	1019	491	42	319	141	768	222
852790	1008	192	91	126	140	645	277
852712	823	253	28	186	88	665	252
852729	778	286	58	221	139	545	279
852692	542	191	15	110	54	408	90
852731	533	180	13	151	79	355	47
852812	467	149	72	90	31	306	159
852520	456	139	23	112	82	298	52
852691	352	82	6	95	46	247	31
852540	295	120	12	88	60	205	15
852719	187	86	11	49	46	135	37
852821	152	73	3	61	35	75	17
852739	130	37	10	17	20	78	7
852813	115	28	3	29	28	71	9
852530	109	45	4	35	24	56	18
852822	95	16	7	10	20	47	17
852510	61	22	1	7	8	36	11
852721	48	17	1	9	6	20	9
852610	46	6	2	10	8	24	7
852691	34	7	0	5	8	18	3
Sample Mean	394	67	22	94	58	277	80
Sample Median	295	62	12	88	46	205	31

Appendix Table 2: Average Number of Entrants

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 Appendix Table 2, 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. On the other hand, for any given destination and product, the number of (realized) exporters tends to be substantially lower (often between 3 and 10). This reflects firms' choices (e.g., in response to destination-specific entry costs).

It may be useful to compare the characteristics of pioneers versus followers to reveal the role of firm heterogeneity. Recall that some consider pioneering activities to occur for purely random reasons; See Wagner and Zahler (2011). In comparison, Melitz-style models tend to imply that a firm with high productivity is more likely to be a pioneer (see Bernard et al., 2007, and Freund and Pierola, 2012, for evidence in this direction). Appendix Table 3 lists some cost and export characteristics of pioneers and followers. Due to data limitations, we only consider three cost variables:[15] (1) whether the firm is a processing exporter; (2) its ownership type; and (3) city-level local wage (using data in year 2000) where the firm is located. Panel A of Appendix Table 3 reports that 40% of pioneer firms engaged in processing trade, compared with 39% for followers. Mean comparison test shows the difference between a pioneer and a follower is not statistically significant. The ownership type seems to matter for a firm's sequence of entry. 57% of pioneers are state-owned enterprises (SOE). As a comparison, 26% of followers are SOEs. 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 the 1% level. However, since many domestic private firms and some foreign invested firms exported through intermediary trading firms, especially before 2002, the role of SOEs might be exaggerated.

Panel B reports the statistical results based on a sub-sample of firms that exclude intermediary firms (i.e., they are all manufacturing firms). 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 the new markets that emerged in 2001 and 2002 in Panel C (385 markets), so as to study the firms' initial characteristics in 2000 before they made entry decisions into new markets. Data show that pioneers have better performance in terms of being a larger exporter, with more relevant export experience in the new market (both on the product side and destination side). Specifically, the average export value of pioneers was US$ 500 million in 2000, compared with US$ 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

[15] 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 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 is 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%
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%
Local wage	1.09	1.15	Significant at 1%
C. Entrant for new market that emerged in 2001 and 2002			
Mean export value in 2000 (US $ million)	500	124	Significant at 1%
Exporter of this product in 2000	43%	9%	Significant at 1%
Exporter to this country in 2000	35%	14%	Significant at 1%

Appendix Table 3: Comparison between Pioneers and Followers

followers.

Note that in our structural model, we allow a firm's marginal cost to be a function of firm ownership, whether it is a processing exporter or not, and local wage rate (as well as of its productivity and other terms).