

Quality Uncertainty and Intermediation in International Trade *

Kunal Dasgupta[†] Jordi Mondria[‡]

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Abstract

In this paper, we examine how the exporting decision and quality choice of producers are affected in the presence of quality uncertainty. We develop a dynamic, two-country model where a foreign consumer learns the quality of a home product only after he has consumed it. As a result, home exporters need to establish reputation about their product in the foreign market. In equilibrium, firm-specific fixed exporting cost arises endogenously; it consists of (i) the cost of establishing reputation in the export market and (ii) the opportunity cost of exporting due to the choice of sub-optimal quality in the home market. The model generates a non-monotonic relationship between firm size and export status, and is consistent with the presence of many small exporters and observed export dynamics. We use the model to analyze the impact of trade intermediaries. By using intermediaries, exporters can avoid the reputation cost in lieu of a higher per unit cost. We show that the effect of intermediaries on the choice of quality and price is much more nuanced compared to what a model with an exogenous intermediation technology would suggest.

KEYWORDS : Intermediaries, quality, uncertainty, screening, asymmetric information, reputation, trade cost.

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[†]Department of Economics, University of Toronto.

[‡]Department of Economics, University of North Carolina at Chapel Hill.

1 Introduction

Uncertainty about product quality is an endemic problem in trade. Figuring out the true quality of a product simply by observing it is not possible for many products; quite often, it may not be possible for the producer to credibly signal the product quality either. This problem of asymmetric information becomes more severe when products are traded across international boundaries, as foreign consumers have even less information on which to base their purchase of an imported product.

In a classic paper, [Rauch and Trindade \(2002\)](#) showed that for differentiated goods, the presence of ethnic Chinese networks in both the trading partners increases trade. Since differentiated goods are those for which quality could vary a lot, the work of [Rauch and Trindade](#) implies that countries trade more when consumers have more information about quality, possibly through ethnic networks. Similarly, [Feenstra and Hanson \(2004\)](#) argue forcefully that one of the reasons why Hong Kong has been successful in intermediating trade between China and rest of the world is because Hong Kong's traders have an informational advantage in identifying Chinese producers who can meet foreign quality standards.¹

Based on the above mentioned studies, it is reasonable to assume that uncertainty about product quality has a dampening effect on international trade. What is less clear is what are the micro-channels through which this uncertainty affects trade. In particular, from the perspective of the consumer, how does uncertainty affect demand? From the perspective of the firm, what barriers do uncertainty create? Is the pricing decision of the firm affected? How is the choice of quality affected, vis-à-vis a world with full information? And finally, does uncertainty lead to selection of some firms into exporting?

In this paper, we put uncertainty about the quality of products in the export market at the forefront of our analysis of exporting behavior.² In Section 3, we develop a two country, overlapping generations model where firms with heterogeneous capability live for two periods and produce different varieties of a quality-differentiated good. The quality of a firm's product is

¹Other papers to provide evidence of informational asymmetry in international trade, although not necessarily about product quality, include [Gould \(1994\)](#) and [Head and Ries \(1998\)](#). [Gould](#) shows that for the U.S., immigrant links to the home country have a strong positive effect on both exports and imports; [Head and Ries](#) find the same for Canada. [Portes and Rey \(2005\)](#) run a standard gravity equation and find that informational flows, proxied by telephone call traffic and multinational bank branches, have significant explanatory power for bilateral trade flows. In a recent paper, [Paravisini et al. \(2010\)](#) show that exporting firms in Peru tend to use those banks for financing which have greater exposure in their destination markets, suggesting a role for information in trade.

²By now, it is well established that quality plays an important role in international trade. Research has shown that not only do rich countries export higher quality goods on average ([Schott, 2004](#); [Hummels and Klenow, 2005](#); [Khandelwal, 2010](#)), but even within narrowly defined sectors, firms produce and export goods of different quality ([Verhoogen, 2008](#); [Kugler and Verhoogen, 2009](#); [Hallak and Sivadasan, 2010](#)).

known in the home market; but it is unknown in the foreign market. Once a foreign consumer consumes the product, he learns its true quality. His knowledge is then transmitted to the rest of the population so that the quality of the product is known in the next period. Given this constraint, a firm chooses the quality of its product, as well as, the price in the different markets in both the periods. In equilibrium, which we study in Section 4, fixed exporting costs arise endogenously. These costs have two components: (i) the cost of establishing reputation in the foreign market and (ii) the opportunity cost of choosing a sub-optimal quality in the home market. Both of these components depend on the quality chosen by a firm and its capability, besides aggregate variables. Our model thus provides a micro-foundation for firm-specific fixed costs that have been used, for example, by [Das, Roberts and Tybout \(2007\)](#) to explain the exporting behavior of Colombian firms.

We show that in a class of pooling equilibria, all “young” exporters charge the same price and sell the same quantity. If the price is low enough, which must be the case if firms are trying to establish reputation, the model is consistent with a number of empirical regularities that have been uncovered recently. First, there are many exporters with small sales. This is consistent with the existence of many small French exporters in the data ([Eaton, Kortum and Kramarz, 2011](#)). Second, it is also consistent with the finding that in a given year, a significant fraction of Chilean exporters are new exporters who export very little compared to those who have exported for at least a year ([Blum et al., 2009](#)). Finally, in our model, all exporters start off small. But the most capable among them experience a growth in sales. Thus, the model is consistent with observed export dynamics of Colombian exporters ([Eaton, Eslava, Kugler and Tybout, 2007](#)). Note that the reason behind the existence of small exporters is very different from the one in [Arkolakis \(2008\)](#). Unlike in [Arkolakis](#), the small exporters in our model are firms at a certain stage in their life-cycle.

The model also provides an explanation for the non-monotonic relationship between size of firms and their export status. [Melitz \(2003\)](#) makes a stark prediction that all exporters are larger than all non-exporters. Of course, we do not expect to see this relationship in the data. But [Hallak and Sivadasan \(2010\)](#) show that the non-monotonicity between firm size and export status is systematic - the fraction of exporters increases with firm size. In our model, uncertainty in the export market distorts the product quality of the exporting firms. This results in some of the exporters earning a lower revenue from home sales compared to some non-exporters. If the revenue from foreign sales is small enough in period one, there would be an overlap between young exporters and non-exporters, at least over some firm size interval. By imposing some restrictions on the underlying capability distribution, our model generates a relationship

between firm size and export size similar to the one uncovered by [Hallak and Sivadasan](#).

After having established the properties of the equilibrium without intermediaries, in Section 5 we allow firms to choose the mode of exporting - firms can choose to “go alone” and directly establish reputation in the foreign market (X exporters), or use intermediaries (I exporters). The prevalence of intermediaries in international trade has recently been uncovered by [Bernard, Jensen, Redding and Schott \(2010\)](#), [Ahn, Khandelwal and Wei \(2010\)](#) and [Blum, Claro and Horstmann \(2009, 2010\)](#), among others.³ In this paper, we choose to highlight the role of intermediaries in providing quality assurances to final consumers. For example, Li & Fung, a multinational trading and sourcing firm based in China claims that they are committed to meeting the demands of international business through “impeccable quality; reliable, on-time delivery; and the highest standards of service”.⁴ Similarly, LCBO, one of world’s largest retailers of beverage claims that “Every product is tasted, tested and certified by the LCBOs Quality Assurance (QA) department”.⁵ Home Depot, the world’s largest home improvement retailer, has a Quality Assurance (QA) program in place which “evaluates supplier performance in the areas of factory, product, and packaging quality”.⁶

In our model, intermediaries have a costly screening technology that allow them to signal the true quality of goods to foreign consumers. Unlike a X exporter who has to bear both components of the fixed exporting cost, an I exporter does not have to incur the reputation cost. But selling through intermediaries also distorts a firm’s choice of quality relative to direct exporting, which results in an implicit higher per unit cost. Intermediation has been modeled in the literature as a technology that allows firms to export using a lower fixed cost but higher variable cost (See [Ahn et al., 2010](#)); we, therefore, provide a micro-foundation for such a technology.

We also find the conditions under which the most productive exporters export directly while the least productive exporters use intermediaries. We show that the quality chosen by a firm exporting through an intermediary could actually be lower than if it had exported directly - a counter-intuitive result. Introduction of intermediaries also leads to some firms switching from being direct exporters to exporting through the former. The effect on the quality of these firms is not uniform, however; while some of the switchers experience a rise in quality, others see

³[Bernard et al. \(2010\)](#) find that pure and mixed intermediaries account for 60 percent of importing firms and 79 percent of importing value in the U.S. Using a technique that surely underestimates the number of intermediaries, [Ahn et al. \(2010\)](#) reports that 22 percent and 18 percent of exports and imports respectively are handled by Chinese intermediaries. Finally, [Blum et al. \(2009, 2010\)](#) find that pure intermediaries account for almost 42 percent of all Chilean imports from Argentina.

⁴www.lifung.com/eng/business/efficiency.php

⁵www.lcbotrader.com/programs_qa.htm

⁶<https://suppliercenter.homedepot.com/wps/portal>

a fall. Finally, the effect of improved efficiency in the intermediation technology on exporter behavior depends on whether the improvement is a result of lower screening costs or higher average ability of intermediaries. Thus the effect of intermediaries on the choice of quality and price is much more nuanced compared to what a model with an exogenous intermediation technology would suggest.

The effect of incomplete information about product quality on consumer's and firm's behavior has been studied extensively by economists. As pointed out by Phillip Nelson in his seminal paper, "information about quality differs from information about price because the former is usually more expensive to buy than the latter" (Nelson, 1970, page 311). The difficulty in determining the true quality of a product induces consumers to engage in costly processes to obtain information about product characteristics. One such process is "search" whereby consumers try to evaluate a product before it is purchased. But when acquiring information in this way is too expensive (for example, when a new product is introduced in the market), consumers might try to determine quality by purchasing or "experiencing" the product.

The sale of such experience goods fundamentally changes the behavior of firms too. Although firms could potentially sell low quality products and make short-term profits, they are dissuaded from doing so by reputational concerns.⁷ Since consumers try to obtain information about a product through consumption, the seller of an experience good essentially bundles information about his product with the product itself; selling a low quality product means providing adverse information about the product that reduces the future stream of profits (Shapiro, 1983b). In such a setting, a firm choosing to sell a high quality product might even have to incur a loss initially to establish reputation in the market.

One way to mitigate this problem of asymmetric information is the introduction of a third party which evaluates the quality of a product.⁸ But quality assurances could also be provided by intermediaries who buy from sellers and sell to final consumers.⁹ In fact, in the presence of asymmetric information, guaranteeing quality is one of the most important roles performed by

⁷See, for example, Schmalensee (1978), Smallwood and Conlisk (1979), Klein and Leffler (1981), Shapiro (1983a) and Riordan (1986).

⁸Examples include Moody's bond ratings or the *U.S. News & World Report's* ranking of college. See Dranove and Jin (2010) for a nice survey on the state of the theoretical and empirical literature on quality assurance.

⁹Of course, there are alternative ways of getting around the problem. For example, firms could provide warranties; if full warranties are given, there will not be any incentive for firms to deviate and quality will be the same as in the complete information case. The problem with full warranties, however, is that it introduces a moral hazard on the consumers' side (Allen, 1984). Since it is difficult to establish whether a product malfunctioned because it was of low quality or whether it was poorly maintained, a full warranty reduces consumers' incentives to use the product properly. Consequently, firms will only give partial warranties and hence reputation will matter again for the firm's choice of quality. In a recent paper, Roberts (2011) shows that warranties cannot substitute for reputation in a decentralized on-line market.

intermediaries ([Spulber, 1996](#)); hence our decision to focus on this role.

2 Related Literature

This paper is related to various strands of the existing literature. As already discussed in the Introduction, there is a large literature on experience goods. Most of the papers in this literature focus on a single market. By allowing firms to sell in two different markets with different informational structures, our model can explain why some firms might choose to serve only one market, i.e., not export even without any exogenous cost of exporting. As we show in this paper, it is the need to establish reputation in the foreign market that generates a cost that acts as a ‘fixed’ exporting cost.

Our paper contributes to the recent but growing literature examining the role of intermediaries in international trade. Motivated by the recent backlash against intermediaries in the developing world, [Anràs and Costinot](#) (forthcoming) present a model where intermediaries provide farmers access to markets. But matching is random, with the rate at which farmers and intermediaries match being determined endogenously. [Anràs and Costinot](#) show that depending on the kind of integration being considered, intermediation could raise or lower welfare of farmers in southern countries. Although we do not explicitly look at welfare, we believe that the presence of intermediaries does have implications for welfare by affecting the equilibrium quality and price of goods. Search frictions also feature in the model of [Blum, Claro and Horstmann \(2010\)](#), who are motivated by the finding that within the universe of Chilean exporters and Colombian importers, there are no small matches - matches between small importers and small exporters do not occur in the data. In their model, firms have an exogenous cost of finding consumers, with this cost being larger for small firms. In equilibrium, small firms match with large intermediaries while the large firms match directly with consumers (who can be thought of as small importers). Facilitating international matches, however, is not the only role of intermediaries that has been studied. [Ahn, Khandelwal and Wei \(2010\)](#) argue that intermediaries arise primarily to overcome trade costs. They augment the Melitz model by adding an intermediation technology; firms have the option of direct exporting or exporting through an intermediary, with the latter entailing a lower fixed cost but a higher per unit cost. The determination of these costs, however, is treated as a black box. In our model, these costs arise endogenously. To our knowledge, the only other paper that theoretically studies uncertainty about product quality and the role of intermediaries in alleviating this uncertainty in an international trade context is [Bardhan, Mookherjee and Tsumagari \(2010\)](#). They develop a model

where an intermediary's (broadly defined) concern for reputation allows it to solve a quality moral hazard problem. [Bardhan et al.](#), however, are interested in the impact of trade liberalization on income distribution. Other theoretical contributions to the literature include [Rauch and Watson \(2004\)](#), [Felbermayr and Jung \(2008\)](#) and [Petropoulou \(2008\)](#).¹⁰

Our paper is also related to several papers that study the role of intermediaries in a closed economy. [Gehrig](#) examines a random matching model where intermediaries and direct trading exist side by side, although he considers only a monopolist intermediary. [Spulber \(1996\)](#) allows for heterogeneity in consumers, producers as well as intermediaries; direct trading, however, is not an option in his model. [Rubinstein and Wolinsky \(1987\)](#) present a model of intermediation where the cost of transaction is endogenous and trade through intermediaries coexist with direct trade. Unlike our model, the market imperfection in their model arises due to the time consuming nature of trade; intermediaries alleviate this problem by shortening the waiting time for buyers and sellers. The paper that is closest to ours is [Biglaiser \(1993\)](#). In his model, sellers are endowed with a good whose quality is not observed by buyers prior to purchasing. Intermediaries differ from buyers because they possess a screening technology. Given this setting, [Biglaiser](#) examines the implication of introducing intermediaries for welfare.

Finally, our paper is related to the theoretical literature on quality in international trade. Most of the papers in this literature have been concerned with explaining the pattern of trade in vertically differentiated goods ([Flam and Helpman, 1987](#); [Stokey, 1991](#); [Murphy and Shleifer, 1997](#); [Fajgelbaum et al., 2009](#)), or the systematic difference in unit value of exports across firms ([Baldwin and Harrigan, 2007](#); [Kugler and Verhoogen, 2009](#); [Hallak and Sivadasan, 2010](#); [Johnson, 2010](#)). We contribute to this literature by introducing a hitherto ignored determinant of quality, asymmetric information, and examining the role of intermediaries in the presence of such market imperfections.¹¹

¹⁰[Rauch and Watson \(2004\)](#) study the formation of intermediation networks and how intermediaries provide access to their network of contacts to other interested parties. Matching and endogenous network building by intermediaries also feature in the work by [Petropoulou \(2008\)](#) while in [Felbermayr and Jung \(2008\)](#), trade intermediaries arise endogenously due to contractual frictions.

¹¹Our paper is also related to the literature on uncertainty in international trade. Most of the papers in this literature focus on how countries formulate trade policy in the presence of uncertainty (See [Ruffin, 1974](#), for example) In contrast, we consider the implications of a different dimension of uncertainty, notably uncertainty about product quality.

3 The Model without Intermediaries

In this section, we develop a framework that will allow us to study the problem of exporters in the presence of asymmetric information about product quality. This framework will also serve as a benchmark against which we can evaluate the effect intermediaries have on firm's decision to export, as well as the choice of quality, quantity and price.

Let there be two symmetric countries - home and foreign. Without loss of generality, we shall carry out our analysis with respect to the home economy. Each country is populated by a unit mass of individuals. Each individual owns one unit of labor that he supplies inelastically in return for a wage of w .

3.1 Preferences

Consumer preferences are captured by an additive random utility model. Let there be J varieties of a differentiated good available to consumers, with the quality of each variety lying between $-\infty$ and ∞ .¹² Each consumer can consume a single unit of a variety. Given quality q_j and price p_j of a variety j , a consumer derives the following utility from consuming a unit:

$$u_j = \theta q_j - p_j + \epsilon_j,$$

where θ captures the preference for quality and ϵ_j is a random variable drawn from a cumulative distribution $\Phi(\epsilon_1, \epsilon_2, \dots, \epsilon_J)$. ϵ_j provides for the possibility that conditional on quality and price, consumers might derive different utility from consuming the same variety.¹³ The probability that a consumer chosen at random will select variety j , f_j , is given by

$$f_j = \text{Prob}(u_j = \max_s u_s), \quad s = 1, 2, \dots, J.$$

Following [McFadden \(1973\)](#), we assume that Φ is a Type I Extreme Value Distribution with

¹²We choose the lower bound for utility as $-\infty$ instead of 0 because of the preferences; it ensures that the demand for the lowest quality variety goes to zero.

¹³The indirect utility function can be obtained from a problem where a consumer allocates his income between a homogeneous numeraire good and one unit of a good of quality q_j and price p_j . Under this interpretation, θ equals the inverse of the marginal utility of income. If the direct utility function is concave, θ is higher for individuals with higher income; richer individuals have a greater preference for quality ([Verhoogen, 2008](#)).

variance σ^2 . The choice probability f_j then reduces to

$$f_j = \frac{\exp\{\frac{1}{\sigma}(\theta q_j - p_j)\}}{\sum_{s=1}^J \exp\{\frac{1}{\sigma}(\theta q_s - p_s)\}}.$$

The derivation of the choice probability from the indirect utility function is quite standard (Interested readers are referred to [Anderson et al. \(1992\)](#)). Assuming that the entire population observes the quality of every variety, f_j gives the fraction of consumers who demand variety j . Observe that f_j is also the actual demand for variety j , since the population has been normalized to one. As the set of available varieties becomes a continuum (number of varieties grows arbitrarily large), the choice density is simply given by

$$f(j) = \frac{\exp\{\frac{1}{\sigma}(\theta q(j) - p(j))\}}{\int_{\Omega} \exp\{\frac{1}{\sigma}(\theta q(s) - p(s))\} ds},$$

where Ω is the subset of varieties that are available to the consumers ([Anderson et al., 2001](#)). In the full information case, $f(j)$ also denotes the demand faced by a producer of variety j . Two features of the above demand function are noteworthy and play an important role in our analysis later on. First, conditional on price, consumers demand more of higher quality varieties. This property captures the vertical differentiation aspect of the differentiated good. Second, as long as $\sigma > 0$, there is positive demand for every variety, *irrespective* of its quality and price. This property reflects the horizontal differentiation aspect of the differentiated good. This latter property also ensures that an equilibrium exists with producers selling varieties of different quality and different consumers having strict preference for different varieties.¹⁴

3.2 Production

Every period, a measure one of firms enter the market, produce for two periods and then exit.¹⁵ Therefore every period, there is a “young” and an “old” cohort of firms. The firms are endowed with some asset that allows them to hire workers at a wage of w and carry out production; this

¹⁴If consumers had identical preferences, then the only way all varieties would have a positive demand is if consumers were indifferent across varieties. This would generate a price schedule for quality, $p(q) = -C_1 e^{-q} + C_2$, where C_1 and C_2 depend on supply factors. The demand for individual varieties would be indeterminate, however.

¹⁵The assumption of firms living for two periods is not essential for our results. We could easily generalize to more than two periods. Adding more periods, however, does not affect our analysis in any significant way.

prevents free-entry.¹⁶ Assuming that producing a new variety is costless, every firm produces a unique variety, and accordingly, has some market power. Firms choose (i) what quality to produce and (ii) how many units to produce (or conversely, what price to charge).

Firms are endowed with capability λ drawn from an exogenous distribution $G(\lambda)$ with density $g(\lambda)$ and support $[0, \bar{\lambda}]$. The technology for producing one unit of quality q is given by

$$q = \lambda + \log(n - \bar{n}),$$

where n is the number of workers used for producing one unit and \bar{n} is the minimum number of workers required to produce a unit; to produce even a variety of quality $-\infty$, a producer has to engage \bar{n} workers per unit.¹⁷ If a firm chooses to produce quality q , the above technology results in a per unit cost of

$$c(q; \lambda) = w(\bar{n} + e^{q-\lambda}).$$

Higher λ allows firms to produce higher quality using the same resources or the same quality using fewer resources.¹⁸ We also assume that producers choose the same quality across time and space. The need for assuming same quality in both periods will be clear once we specify the information structure. Requiring firms to choose the exact same quality in both the home and foreign markets is without loss of generality. We could allow firms to choose different qualities in the two markets; but all our results will hold as long as there is some linkage between the two qualities, i.e., as long as the choice of quality in one market affects quality in the other market. This, again, will become clear later on.¹⁹

3.3 Information

Home consumers observe all firm-specific variables of domestic firms. In particular, the quality of the varieties produced by home firms is observed by home consumers in both periods.

¹⁶In the heterogeneous firm literature following Melitz (2003), the standard assumption has been that any firm can carry out production by incurring a cost upfront. As shown by Evans and Jovanovic (1989), however, entrepreneurship may not be an option for many individuals because of liquidity-constraints. Heterogeneous firm models with a fixed number of firms include Chaney (2008) and Arkolakis (2008).

¹⁷The term “capability” was introduced by Sutton (2007); capability is similar to productivity, but in a world where goods have heterogeneous quality. Although, capability has two dimensions in Sutton’s work, we reduce it to a single dimension captured by λ (See Kugler and Verhoogen, 2009, for a similar treatment).

¹⁸The functional form for $c(q; \lambda)$ is convenient, but not necessary. What is necessary is that the marginal cost function displays the following property: $\frac{\partial^2 c}{\partial \lambda \partial q} < 0$.

¹⁹Firms would choose the same quality in both the periods if it is very costly to change quality midway through production. The linkage between the qualities of the varieties produced for the home and the foreign markets would arise if, for example, the production lines cannot be separated completely.

Accordingly, the demand faced by a home producer in the home market is given by

$$x_{d,H}(j) = f(j). \quad (1)$$

Foreign consumers, on the other hand, do not observe the quality of a variety produced by a “young” home exporter. Quality is revealed in the second period when the firm is “old”, provided that there has been some consumption of the variety.²⁰ But the revelation of quality in the second period depends on the excess demand for the good in the foreign market in the first period.

Let the amount of good that a young exporting firm chooses to supply to the foreign market be $x_{s,F}^1$. Let the demand facing the firm be $x_{d,F}^1$. In the second period, foreign consumers receive a noisy signal: with probability α they observe the true quality of the good and with probability $1 - \alpha$, they observe a quality of $-\infty$, where $\alpha = \alpha(x_{d,F}^1 - x_{s,F}^1)$ with the following properties :

$$\alpha' \leq 0; \quad \alpha(0) = 1; \quad \alpha(x_{d,F}^1) = 0.$$

As long as a firm has $x_{d,F}^1 - x_{s,F}^1 > 0$, there are some unsatisfied consumers. These consumers perceive the firm as providing very poor service. We think of quality as any attribute of a product, including the service provided by the firm selling that product, that consumers value. Accordingly, these unsatisfied consumers spread the message around that the firm is selling a variety with quality $-\infty$. On the other hand, the consumers whose demand is satisfied reveal the true quality of the variety. In the second period, consumers acquire information about this variety from those who had consumed, as well as, those who wanted to but could not consume the good in the previous period. The probability of receiving a signal from someone who had consumed the good depends on the size of excess demand. Higher is excess demand, greater are the chances of meeting an unsatisfied customer and receiving a signal that quality is $-\infty$. For example, (Morawetz, 1981) argues that the decline of Colombian export of clothing in the mid-70s was partly due to the gradual realization by U.S. buyers that Colombian suppliers are not reliable due to their inability to deliver orders on time.²¹

²⁰It should now be clear why we need more than one period. Since exporters sell an experience good, with only one period, the export market would suffer from Akerlof’s lemons problem (Akerlof, 1970); only the low quality producers would export. This problem can, however, be mitigated even in a one period model if there are some informed consumers (See Cooper and Ross, 1984).

²¹The world wide web is a platform through which agents meet each other and exchange information about goods. After consuming a good, both satisfied and unsatisfied consumers post their experience on websites and on-line forums. Higher is the proportion of negative reports about a good, greater is the probability that a potential consumer will believe that the good is of low quality. Chevalier and Mayzlin (2006) discusses the relevance of word-of-mouth communication among consumers and how it affects the sell of books online.

By applying the Law of Large Numbers, we then conclude that for any measure of consumers, the fraction who know the true quality of a good is α . In particular, among those consumers who *would have* consumed the good in the event that everyone knew the true quality in the second period, only a fraction α would actually want to consume the good. Hence, the demand faced by an old exporter in the foreign market is

$$x_{d,F}^2(j) = \alpha(x_{d,F}^1 - x_{s,F}^1)f(j). \quad (2)$$

The only difference between the above expression and equation 1 lies in α . Asymmetric information scales down demand, as long as young exporters do not meet their demand in the foreign market. A natural question to ask is, why a young exporter would want to supply less than the demand it faces. This possibility would arise if the firm is making losses per unit sold. Then it would ideally want to sell as little as possible. But selling less in period one results in reduced demand in period two when it could potentially make profits. In fact, later on we show that old exporters always earn profits in the foreign market, where profits are proportional to the quantity sold.²² Hence, a young exporter that incurs a loss in the foreign market faces a trade-off.

At this point, it is instructive to point out the difference with [Arkolakis \(2008\)](#). In his paper, exporters have to bear a positive cost of reaching even the first consumer in any market. Our model suggests that reaching a single consumer may not be optimal for an exporter; even though the cost of selling one unit in the foreign market is negligible, the foregone profits could be large, depending on how productive the exporter is. For the remainder of the paper, we shall assume that α is such that it is *never profitable* for a young exporter to supply less than its demand.²³

The timing of the model is depicted in Figure 1. Given the informational structure, it should now be clear why we require producers to produce the same quality across time. If exporters could separately choose their quality in the foreign market in the two periods, they would never choose $q > -\infty$ when they were old. Anticipating this, foreign consumers would demand zero

²²If an exporter makes losses in both periods, it should simply exit the export market.

²³For example, the following function would ensure that:

$$\begin{aligned} \alpha &= 1 && \text{if } x_{d,F}^1 = x_{s,F}^1 \\ &= 0 && \text{otherwise} \end{aligned}$$

When α takes this functional form, a firm either meets demand in period one or it does not export. Supplying an amount that is positive but less than $x_{d,F}^1$ is strictly dominated by supplying nothing. In general, the more convex is α , more costly it is for the firm to keep supply below demand in the export market.

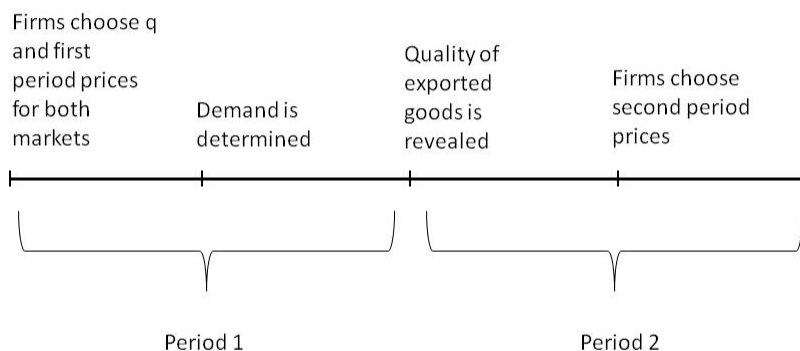


Figure 1: *Timing of the model*

units from these exporters in period two.

4 Equilibrium

Since selling in the home market does not involve asymmetric information, we first consider the problem of the firm in a closed economy. We then go on to study the open economy equilibrium.

4.1 Closed economy

Every firm produces a unique variety and solves the following problem:

$$\max_{p,q} 2[p - c(q; \lambda)]x_{d,H}(q)$$

where $x_{d,H}(q)$ is given by equation 1. We multiply the expression by 2 because of the two periods. Profit-maximization yields the following:

$$q^D(\lambda) = \lambda + \log \frac{\theta}{w}. \quad (3)$$

$$\begin{aligned} p^D(\lambda) &= \sigma + w(e^{q^D - \lambda} + \bar{n}). \\ &= \sigma + \theta + w\bar{n}. \end{aligned} \quad (4)$$

Although more capable firms produce higher quality varieties, every firm that serves only the home market charges the same price. The price charged is a constant markup σ over marginal cost $w(\bar{n} + e^{q^D - \lambda})$, where $w e^{q^D - \lambda}$ happens to be equal to a constant θ . Essentially, there are

two forces that determine how marginal cost changes with capability. More capable firms face a lower cost of producing a *given* quality of a variety. But more capable firms also choose higher quality which raises their marginal cost. Given the functional forms used in this paper, these two effects cancel each other out exactly, whereby marginal cost is independent of λ . In general, whether marginal cost rises or falls with capability will depend on which of these two effects dominate.

The price charged depends on σ , the dispersion in the taste of the consumers. Intuitively, a high σ increases the mass on the tails of the distribution of ϵ . Since the demand for a particular quality comes from individuals who value it highly (i.e., those in the upper tail), fattening of the upper tail raises demand, while fattening of the lower tail has no effect on demand. The price is also higher if consumers attach higher value to quality (higher θ). Replacing the value of $q^D(\lambda)$ and $p^D(\lambda)$ in the expression for profit, we get

$$\pi^D(\lambda) = \frac{2\sigma}{C} \exp\left\{\frac{1}{\sigma}(\theta\lambda + \theta \log \frac{\theta}{w} - \sigma - \theta - w\bar{n})\right\}. \quad (5)$$

where $C = \int_{\Omega} \exp\left\{\frac{1}{\sigma}(\theta q(j) - p(j))\right\} dj$ is a measure of aggregate demand. The above equation suggests that $\pi^D(\lambda)$ is equal to $\tilde{C} \exp\left\{\frac{\theta\lambda}{\sigma}\right\}$, where \tilde{C} is a constant from the firm's perspective. In equilibrium, more capable firms sell higher quality at the same price and face higher demand, resulting in higher profits. Observe that if a firm chooses to serve only the home market, both quality and price charged by the firm will remain unchanged even in the open economy.

4.2 Open economy

Before formally defining the equilibrium in the open economy, let us point out the difference between the problem faced by foreign consumers and young home firms in our model and the standard "lemons" problem. In the standard model, the principal values an asset that the agent provides. The value of the asset, however, varies across agents, which the principal does not observe. Hence, the latter offers an average price for the asset, where the price depends on the belief of the principal regarding the distribution of assets. The strategy for the agents is to accept or reject the price.

In our model, firms are not price-takers. They choose their price in both the home, as well as, the foreign market. In particular, young firms can use their price to signal their quality in the foreign market. Consumers have rational expectations. At the beginning of period one, foreign consumers correctly anticipate the expected quality of the young exporting firms, \bar{q} , although they cannot observe the quality of individual firms. Upon observing the price charged by a

young firm, foreign consumers update their belief about that firm's quality, $\mu(q|p)$. Based on the price and the updated belief about quality, demand for the variety $x_{d,F}^1$ is generated, which, as we have already assumed, is met by the producers.

Given the structure of the problem, we shall use the concept of a perfect Bayesian equilibrium (PBE). PBE requires a strategy profile for the agents and posterior beliefs about the type. In this model, the strategy for a consumer (both home and foreign) is to demand a variety; the strategy for a firm is to choose a quality, q , and prices for each market. The posterior belief, $\mu(q|p)$, is about the quality of the variety sold by a firm. Formally,

Definition 1. *A PBE of the model consists of strategies for the consumers and firms, and posterior beliefs such that:*

- (a) *Consumers' maximize utility,*
- (b) *Firm's maximize profits,*
- (c) *$\mu(q|p)$ is formed from the prior distribution using Bayes' rule whenever possible.*

Note that unlike the standard signaling game, the prior distribution of quality in this model is endogenous since it involves choice by the firm that in turn depends on equilibrium price and quantity demanded. Hence, the prior beliefs must be simultaneously solved in equilibrium.

Let the the profit from serving both markets be denoted by $\pi^X(\lambda)$. A firm, when choosing whether to export or serve only the home market, compares $\pi^D(\lambda)$ with $\pi^X(\lambda)$. It should be clear that in equilibrium, if a firm chooses to export in the first period, it will do so in the second period too. In the second period, the quality of an exporter is fully revealed, whereby he solves a full information problem. For a given quality q , the optimal second period price of the exporter is given by $\sigma + w(\bar{n} + e^{q-\lambda})$. Since marginal cost is $w(\bar{n} + e^{q-\lambda})$, the exporter earns a profit of σ per unit of output sold. Hence, irrespective of the quality of goods sold, a firm would always want to export in the second period, if it has exported in the first period. The possibility that a firm exports in the second period but not the first is ruled out by the fact that if a firm does not export in period one, it faces the problem of a young exporter in period two. Hence, if exporting was not profitable in period one, it cannot be profitable in period two either. ²⁴

The problem of an exporter then reduces to choosing a quality and a price for the foreign market in period one. Given quality, the exporter charges the full information price in all the other three markets (the home market in period one and two, and the foreign market in period two). The price it charges in the period one foreign market, however, depends on the posterior

²⁴Note that this argument relies on the economy being in a stationary equilibrium. In a non-stationary equilibrium, an exporter might choose to export in period two but not in period one if the equilibrium price in period two is substantially higher than the one in period one.

belief held by the foreign consumers about its quality. In this paper, we restrict our attention to pooling equilibria where every young exporter charges the same price, let us call it \bar{p} , in the foreign market. In fact, within the class of pooling equilibria, we focus on *perfect sorting equilibria*, i.e., equilibria in which there exists a λ^X such that all firms with capability above λ^X export and the rest do not. We start by characterizing the set of price that can be sustained in an equilibrium. In order to do so, first we make the following assumption:

Assumption 1. *A firm cannot sell a good at a price below its marginal cost of production if that cost is observed by consumers.*

Assumption 1, which is essentially an anti-dumping condition, gives us a lower bound for the equilibrium price.²⁵ To see this, note that although consumers do not observe the quality or the capability of an exporting firm, they know that the marginal cost of producing a quality q by a firm with capability λ cannot be less than the marginal cost of producing quality $-\infty$ (the lowest quality) by the most capable firm. Since this cost is $w\bar{n}$, the equilibrium price \bar{p} must be weakly greater than $w\bar{n}$. As the following lemma shows, we can also put an upper bound on \bar{p} .

Lemma 1. *In a pooling equilibrium with perfect sorting, \bar{p} must be less than $\theta + w\bar{n}$.*

The condition for a perfect sorting equilibrium is stronger than the condition for a sorting equilibrium, where some firms, but not necessarily the most capable firms, export. Our focus on the former is due to the widespread use of this equilibrium following the seminal work of [Melitz \(2003\)](#).

Assumption 1 and Lemma 1 together imply that $\bar{p} \in \mathbb{P}$, where $\mathbb{P} = [w\bar{n}, \theta + w\bar{n}]$. The simplest way to support a $\bar{p} \in \mathbb{P}$ as a pooling equilibrium is to assign pessimistic beliefs $\mu(q = \bar{q} | p = \bar{p}) = 1$ and $\mu(q = -\infty | p \neq \bar{p}) = 1$. It is easy to see why such beliefs would dissuade any firm from deviating. If a firm chooses to export, then its net profit from the foreign market must be positive (even if the first period profit is negative). Since $x_{d,F}^t = 0 \forall t$ if $q = -\infty$, deviating from \bar{p} would reduce the exporting profits of a firm to zero.

PBE allows the consumers to assign any posterior belief whenever $p \neq \bar{p}$. This leeway in specifying off-the-equilibrium-path beliefs generates multiple equilibria ([Fudenberg and Tirole, 1991](#)); with pessimistic beliefs as defined above, any $\bar{p} \in \mathbb{P}$ can be supported as the equilibrium price. We can, however, provide a stronger characterization of the equilibria set if we allow the

²⁵The Agreement on Implementation of Article VI of GATT 1994, commonly known as the Anti-Dumping Agreement, allows countries to impose duties on a product if it can be proved that the product is being dumped. One of the ways in which it can be shown that a country is dumping a particular product is by comparing its export price with its “constructed value” which consists of cost of production and other expenses.

agents to play only pure strategies. In this case, as the following lemmas show, the pessimistic beliefs are not only sufficient, but under certain conditions, are also *necessary* to support a pooling equilibrium.

Lemma 2. *In a pooling equilibrium with perfect sorting, if the equilibrium price \bar{p} is such that $\bar{p} < c(q^X(\bar{\lambda}); \bar{\lambda})$ where q^X is the equilibrium quality of an exporter, the Foreign consumers' beliefs must take the following form : $\mu(q = \bar{q}|p = \bar{p}) = 1$ and $\mu(q = -\infty|p > \bar{p}) = 1$, where \bar{q} is the expected quality of the exporting firms.*

Lemma 3. *In a pooling equilibrium with perfect sorting, if $w\bar{n} < \bar{p} < c(q^X(\bar{\lambda}); \bar{\lambda})$, then the Foreign consumers' belief must be $\mu(q = -\infty|p < \bar{p}) = 1$. If, on the other hand, $\bar{p} = w\bar{n}$, then the following belief can also sustain an equilibrium : $\mu(q = q_H|p < \bar{p}) = 1$ where $q_H > \bar{q}$.*

Lemmas 1, 2 and 3 provide us with necessary conditions for the existence of a pooling equilibrium with perfect sorting. The requirements for a perfect sorting equilibrium narrows down the set of prices and beliefs that can sustain such an equilibrium considerably. Of course, whether a strategy-belief tuple belonging to this set is in fact a perfect sorting equilibrium will depend on how $\pi^X(\lambda)$ compares with $\pi^D(\lambda)$.

When a firm chooses to export, it essentially faces two kinds of market - the foreign market in period one with asymmetric information and the other three markets which have full information. Since the full information markets are identical, the firm chooses the same price in these three markets. Let this price be denoted by $\hat{p}(\lambda)$. Henceforth, we drop the argument on firm prices and qualities to make the exposition simple. Given that a firm chooses a price of \bar{p} in the first period for the foreign market, its profit from serving all the four markets is given by

$$\begin{aligned}\pi^X(\lambda) &= \max_{q, \hat{p}} \pi^X(q; \lambda) \\ &= \max_{q, \hat{p}} [(\bar{p} - w(\bar{n} + e^{q-\lambda})) \frac{1}{C} \exp\{\frac{1}{\sigma}(\theta\bar{q} - \bar{p})\} + \frac{3\sigma}{C} \exp\{\frac{1}{\sigma}(\theta q - \hat{p})\}].\end{aligned}$$

$\frac{1}{C} \exp\{\frac{1}{\sigma}(\theta\bar{q} - \bar{p})\}$ denotes the expected demand for the home firms' varieties in the foreign market.²⁶ Let the profit-maximizing quality be denoted by q^X . Then we can re-write the firm's

²⁶The expected utility from consuming varieties sold by the young home firms is given by

$$\begin{aligned}E_q[v(q)] &= \theta E_q[q] - E_q[p(q)] + \eta, \\ &= \theta\bar{q} - \bar{p} + \eta, \\ &= v(\bar{q}),\end{aligned}$$

where $\bar{q} = E_q[q]$. This is an attractive feature of the additive random utility model, and will not be true in general.

profit as

$$\pi^X(\lambda) = (\bar{p} - w(\bar{n} + e^{q^X - \lambda})) \frac{1}{C} \exp\left\{\frac{1}{\sigma}(\theta\bar{q} - \bar{p})\right\} + \frac{3\sigma}{C} \exp\left\{\frac{1}{\sigma}(\theta q^X - \sigma - w(\bar{n} + e^{q^X - \lambda}))\right\}, \quad (6)$$

where we have used the result that $\hat{p} = \sigma + w(\bar{n} + e^{q^X - \lambda})$. The first-order condition for profit-maximization yields

$$w \exp\left\{q^X - \lambda + \frac{1}{\sigma}(\theta\bar{q} - \bar{p})\right\} = 3 \exp\left\{\frac{1}{\sigma}(\theta q^X - \sigma - w(\bar{n} + e^{q^X - \lambda}))\right\} (\theta - w e^{q^X - \lambda}). \quad (7)$$

The above equation implicitly defines q^X as a function of the parameters. A firm compares $\pi^D(\lambda)$ with $\pi^X(\lambda)$ and chooses the maximum. Equation 6 seems to suggest that everything else remaining the same, lower is \bar{p} , more likely it is that some firms choose not to export. This is an important insight that we develop further below. In this model, firms cannot directly signal their quality. If \bar{p} is sufficiently small, firms incur a loss in period one from exporting. This loss, captured by the first term on the right-hand side of equation 6, represents the cost of establishing reputation in the foreign market. But this is not the only cost that exporters have to bear. To see this, observe that the second term on the right-hand side of equation 6 can be broken down as

$$\frac{3\sigma}{C} \exp\left\{\frac{1}{\sigma}(\theta q^X - \hat{p})\right\} = \underbrace{\frac{3\sigma}{C} [\exp\left\{\frac{1}{\sigma}(\theta q^X - \hat{p})\right\} - \exp\left\{\frac{1}{\sigma}(\theta q^D - p^D)\right\}]}_{\text{opportunity cost}} + \underbrace{\frac{3\sigma}{C} \exp\left\{\frac{1}{\sigma}(\theta q^D - p^D)\right\}}_{\text{full information profit}}. \quad (8)$$

The cost of establishing reputation in the foreign market introduces a trade-off for potential exporters. The assumption that firms produce goods of the same quality for all the markets implies that exporting affects the choice of quality in the home market. Producing q^D maximizes profits in the full information markets. On the other hand, lowering quality below q^D reduces losses (raises profits) for young firms in the foreign market.²⁷ In equilibrium, firms end up choosing $q^X < q^D$; there is an opportunity cost of exporting. For the less capable firms, the additional profit from exporting in period two is not sufficient to cover the loss from (i) reputation costs and (ii) less than optimal quality at home. Hence, they choose to stay domestic and produce the full-information quality. We state this result formally in the following proposition.

For example, in order to generate CES preferences, utility must be log-linear in quality, whereby $E_q[v(q)] \neq v(E_q[q])$.

²⁷The choice of quality does not affect demand faced by individual firms. But it determines per unit profits, $\bar{p} - w(\bar{n} + e^{q^X - \lambda})$, which is decreasing in q^X .

Proposition 1. *If $3(\frac{3}{2}e^{\frac{2}{3}} - 1)w > \sigma > \theta$, then for \bar{p} sufficiently small,*

- (i) *there exists λ^X such that firms with $\lambda > \lambda^X$ export while the rest sell only domestically, and*
- (ii) *both q^D and q^X are increasing in λ with $q^D > q^X$.*

Under what conditions do we have a perfect sorting equilibrium? As Proposition 1 states, a perfect sorting equilibrium is more likely if σ , which captures the dispersion in tastes of consumers, lies in a bounded interval. The intuition is as follows: The difference between $\pi^D(\lambda)$ and $\pi^X(\lambda)$ depends on the extent of the distortion in quality, i.e., by how much q^X falls short of q^D . The bigger the difference between the two, the greater is the opportunity cost of exporting. The distortion in q^X , in turn, depends on the value of σ . On the one hand, firms would like q^X to be as close to q^D as possible. On the other hand, higher q^X implies higher marginal cost, which increases the losses (or reduces profits) in the period one foreign market. The extent to which firms can recover these losses from the full information markets depends on how high a price they can charge in these markets. Higher is σ , greater is the heterogeneity in tastes meaning that firms can raise their price without affecting their demand too much. In other words, if σ is too small, the losses from exporting would be high for every firm, with the result that all firms might end up not exporting. This creates a lower bound for σ . An analogous argument shows that if σ is too large, exporting is attractive for every firm, with the result that all firms end up exporting. This, in turn, creates an upper bound for σ . The likelihood of a perfect sorting equilibrium also depends on w lying in a bounded interval. w determines the marginal cost of production; a higher w increases the first period losses in the foreign market, thereby reducing the attractiveness of exports. Like σ , a low enough w would make all firms export while a high enough w would prevent any firm from exporting. The equilibrium choice of quality is shown in Figure 2.

A possible interpretation of Proposition 1 is that when a firm enters the export market following trade liberalization, it downgrades the quality of the good that it produces. Evidence from Mexico provided by [Iacovone and Javorcik \(2010\)](#) shows that firms that enter the export market experience an increase in the unit value of their products in anticipation of exporting. Similarly, [Verhoogen \(2008\)](#) finds that firms that expand their exports following the peso devaluation crisis see an increase in ISO 9000 certification. Both pieces of evidence are suggestive of some sort of quality *upgrading* due to better exporting opportunities, not quality downgrading. We should point out that our model is not inconsistent with the above mentioned findings. To see this, note that there are two main theories behind quality upgrading - (a) the hypothesis of [Alchian and Allen \(1964\)](#) that rests on per unit transportation costs and (b) a higher willingness to pay for quality by foreign consumers, possibly due to lower marginal utility of income.

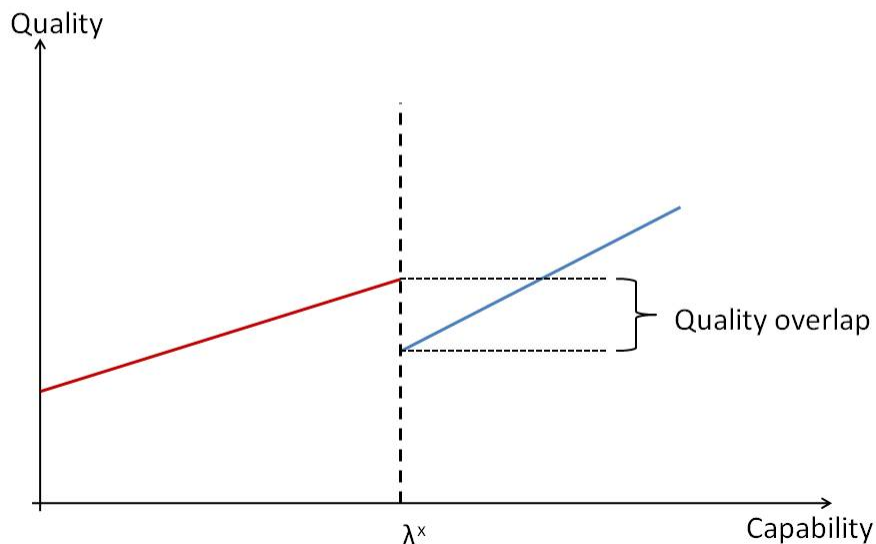


Figure 2: *Equilibrium quality as a function of capability*

Our model features zero transportation costs and symmetric countries. Once we drop either one of these two assumptions, our model would also generate quality upgrading by some, if not all, exporters. Note, however, that even if some firms engaged in quality upgrading, they would continue to incur an opportunity cost of exporting. It is the assumption that firms are constrained to choose the same quality in all markets, and *not quality downgrading*, that makes exporting costly.

Relation between size and export status: The uncertainty in quality breaks a standard feature of the generic heterogeneous firm model - the monotonic relation between size and capability, where size is measured in terms of sales. In the standard model, there is a discontinuity in size at the threshold λ^X ; the size increases because exporting firms have to incur the fixed exporting cost. For the young cohort of firms in our model, there is a similar discontinuity at λ^X , as shown in Figure 3. But unlike in the standard model, under certain conditions, the size of an exporter *falls*. This opposite outcome arises again due to a choice of quality by the marginal exporter that is not optimal for the home market anymore. The marginal exporter experiences a drop in sales from the home market. If the sales from the foreign market are small enough (which would be the case if \bar{p} is small), the total sales of the marginal exporter, and by continuity some of the smaller exporters, is less than the marginal non-exporter. For some capability distributions, the drop in sales of the young exporters generates a well-behaved

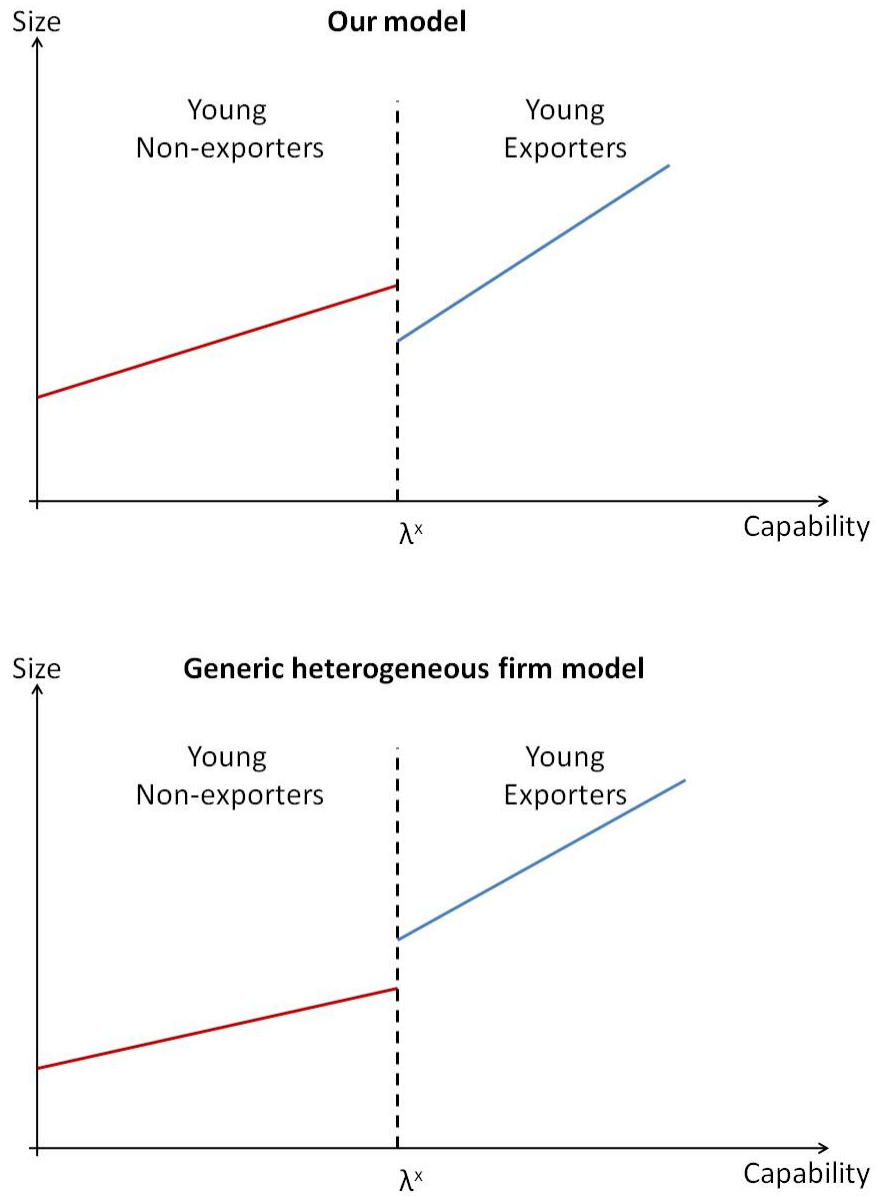
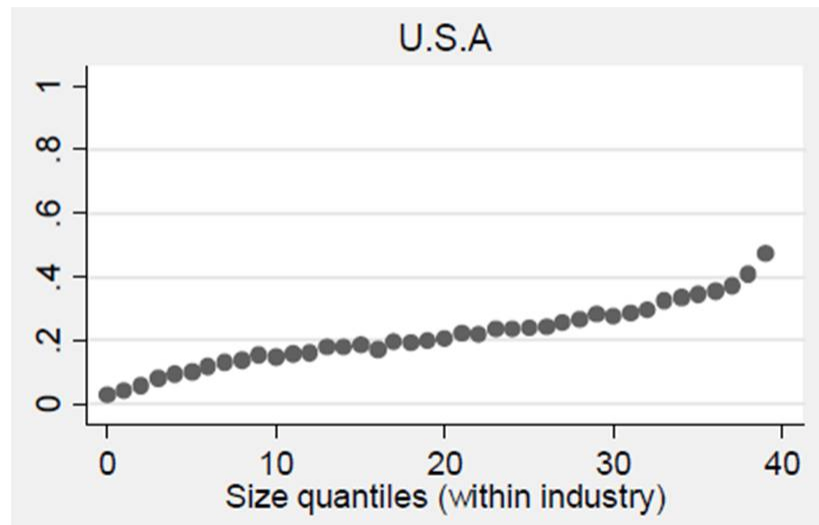
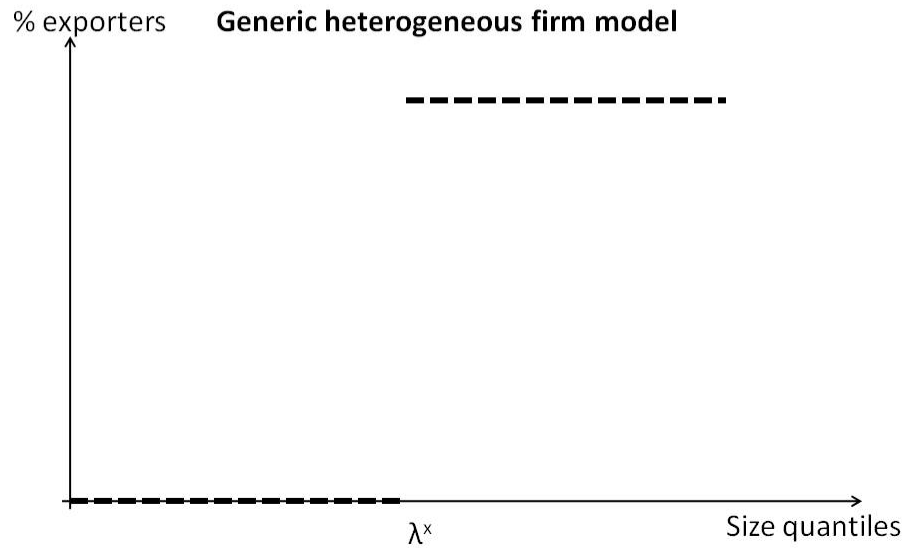


Figure 3: Firm size of the “young” cohort



Hallak & Sivadasan (2009)

Figure 4: *Percentage of exporters in each size quantile*

relation between percentage of exporters and size quantiles of home firms. For example, if we assume a truncated Pareto distribution for capability, the percentage of exporters in each size quantile increases as we move to higher quantiles, as shown in the following proposition.²⁸

²⁸A truncated Pareto distribution can be justified on the grounds that the largest firms in an industry already have a good reputation in the export market and hence, the problem of uncertain quality does not apply to them.

Proposition 2. *If the capability distribution $G(\lambda)$ is a truncated Pareto, then the percentage of young exporters is an increasing function of the firm size quantiles.*

The increasing relation between percentage of exporters and size quantiles contrasts sharply with the perfect sorting of export status by size in the standard model, shown in the top half of Figure 4. The bottom half, reproduced from Hallak and Sivadasan (2010), presents evidence on the relationship between percentage of exporters and size quantiles from the U.S. Hallak and Sivadasan uncover a similar pattern in the data for Chile, India and Colombia. In their model, this relation arises due to a similar non-monotonicity between quality and firm size. In Hallak and Sivadasan, firms are required to meet minimum quality standards in order to export. Their model also features a second degree of heterogeneity (on top of the heterogeneity in capability) in firms' ability to produce quality. The quality constraint effectively "distorts" a firm's choice; combined with two dimensional heterogeneity, this generates a non-monotonic relationship between size (determined by capability) and export status (determined by quality). Although firms in our model are differentiated with respect to a single attribute, capability, the cause for non-monotonicity is a distortion caused by the requirement to establish reputation (and an opportunity cost). So, although the two models are quite different, the cause for non-monotonicity is, at a deeper level, quite similar.

Endogenous fixed and sunk costs of exporting: The model generates endogenous firm-specific fixed exporting costs (Das et al., 2007; Eaton et al., 2011). A part of these costs take the form of foregone revenues in the home market. Note that this cost depends on quality (see equation 8) and accordingly, affects the firm's choice of quality. But the cost is "fixed" in the sense that conditional on quality, an additional unit produced by a firm is not affected by this cost. Furthermore, the cost of reputation acts as an additional fixed cost, and like the opportunity cost, depends on the quality chosen by the firm. As long as \bar{p} is low enough, the exporting firm incurs a loss in the first period foreign market; higher is the quality, greater is the loss.

In this model, firms do not face any uncertainty. Even though foreign consumers do not observe the quality of varieties sold by home exporters in the first period, the quality is known exactly in period two. Consequently, firms know the demand facing them in the period two foreign market for every quality. Now, consider the following modification to the model: Suppose at the beginning of period two, foreign consumers receive a public signal that the quality of a variety is $-\infty$ with some positive probability. In this modified model, firms face uncertainty; some of them will have zero export demand in period two.²⁹ In this situation, both the opportunity cost and reputation cost acts like sunk costs; a firm has to incur these costs if it wants to

²⁹This difference does not arise due to our assumption that $\alpha = 1$ in equation 2. Suppose $\alpha < 1$. Since α

export, but these are sunk once it has entered the foreign market. The reputation cost has to be incurred in period one and cannot be recovered if the firm decides not to export in period two. As for the opportunity cost, since the firm cannot change quality in period two, the revenue in the period two home market continues to be lower (relative to the full information case), even if the firm chooses not to export.

Abundance of small exporters: In the Melitz model, there is a fixed cost of exporting that is the same across firms; the implication is that only the most capable firms in an industry export. In order to export, firms should be able to generate large enough sales in the export market; this leads to the discrete jump in size at λ^X in the top half of Figure 3. Eaton et al. (2011) find the existence of many small French exporters in the data, which is not consistent with the Melitz model. One possible explanation has been provided by Arkolakis (2008). He argues that firms do not face a uniform fixed cost; rather, the fixed cost depends on the number of consumers reached by the firm. The small exporters observed in the data are firms which are capable enough to reach the first foreign consumer but not capable enough to reach too many of them. Consequently, their sales are low.

Our model provides an alternative explanation for the abundance of small exporters in the data. The young exporters do not need to have high sales in the foreign market to cover some fixed exporting cost; as discussed earlier, the fixed exporting costs are partly foregone sales at home. Rather, these exporters need to have low enough sales in period one so as to build reputation for their product in the foreign market. This mechanism is partly responsible for the discrete drop in size at λ^X in the bottom half of Figure 3. Therefore, when looking at a cross-section of exporters, one would always observe many small firms. These are simply the young firms who are trying to build reputation.

Exporter dynamics: Our model has implications for how the volume of exports change over time. In particular, our model predicts that the more capable firms will increase their exports between periods one and two. Since the quality of exporters is unknown in the first period, the initial demand facing the more capable exporters is low. But once their true quality is revealed, the demand for their product rises. Work done on Colombian firms by Eaton et al. (2007) seems to suggest that indeed there are firms that experience growth in the export markets over time.³⁰

captures the probability of private signals, the demand facing a firm is deterministic by the Law of Large Numbers. Although some foreign consumers might get a signal that the quality of a variety is $-\infty$, others will know the true quality. With public signals, however, every consumer has the same belief. Of course, we are assuming that consumers ignore their private signals, if there are any.

³⁰Rauch and Watson (2004) cite evidence indicating that developed country buyers start small when purchasing from developing country suppliers and then increase order size as the suppliers' ability to meet quality is revealed.

The same study provides evidence that it is much more likely for a firm to export in a particular period if it has exported in the previous period.³¹ Our model provides a rationale. The problem faced by a firm that has already exported is quite different from a firm that has not - the former has already established a reputation in the foreign market. Hence it is more likely to export in the future. The dynamic behavior of firms in our model is also consistent with the finding in [Blum et al. \(2009\)](#) that in a given year, a significant fraction of Chilean exporters are new exporters who export very little compared to those who have exported for at least a year.

To sum up, despite being quite stylized, our model is consistent with a number of features in the data. In the next section, we introduce trade intermediaries and examine how their availability affects the exporting behavior of firms.

5 The Model with Intermediaries

Intermediaries are firms in the destination market ([Blum et al., 2009](#)). We assume that there is a measure $M < 1$ of intermediaries in each country. Intermediaries have ability γ distributed according to an exogenous distribution $F(\gamma)$ with $\gamma \in [\underline{\gamma}, \bar{\gamma}]$. Consistent with our assumption about the information structure, foreign consumers observe the ability of foreign intermediaries.

Each intermediary has access to a screening technology. Using this technology, intermediaries can find out whether the output of a firm is of a given quality or not. Let us denote the cost of screening quality q by a γ ability intermediary by $s(q; \gamma)$. The cost that a foreign intermediary incurs on screening is observed by foreign consumers.³² The cost function has the following properties :

$$\frac{\partial s}{\partial q} > 0; \frac{\partial s}{\partial \gamma} < 0; \frac{\partial^2 s}{\partial^2 q} > 0; \frac{\partial^2 s}{\partial q \partial \gamma} < 0.$$

Screening higher quality is more costly. A natural interpretation is that higher quality goods have more attributes or features; hence an intermediary has to incur more effort in order to test each one of those features. But exerting effort is less costly for more able (higher γ) intermediaries. Furthermore, $s(q; \gamma)$ exhibits the single-crossing property - the cost of screening higher quality rises slowly for more able intermediaries.

³¹ Similar findings are reported in [Roberts and Tybout \(1997\)](#) and [Bernard and Jensen \(2004\)](#).

³² We could relax this assumption by assuming instead that the intermediaries care about their own reputation which dissuades them from cheating the foreign consumers ([Biglaiser and Friedman, 1994](#)).

5.1 Equilibrium

The equilibrium is characterized by a supplier price schedule $p_s(q)$, the price paid by the intermediaries to the suppliers, which every intermediary and home firm takes as given. The home firms then choose what quality to produce and approach the intermediaries who screen quality and pay the announced price. We assume that $p_s(q)$ is observed by everyone.

Given $p_s(q)$, an intermediary chooses the quality of the good that it wants to trade. This problem can be viewed as a two-stage game. In the second stage, given a quality q , an intermediary with ability γ chooses the final (consumer) price $p_c(q)$ to maximize its profit $r(q; \gamma)$:

$$\max_{p_c(q)} r(q; \gamma) = [p_c(q) - p_s(q)] \frac{1}{C} \exp\left\{\frac{1}{\sigma}(\theta q - p_c(q))\right\} - s(q, \gamma),$$

where the demand for quality q depends on $p_c(q)$ and not $p_s(q)$. The solution to the above problem gives the optimal price charged by the intermediary to consumers :

$$p_c(q) = \sigma + p_s(q). \quad (9)$$

Note that the screening cost does not affect $p_c(q)$ directly because it is not a per unit cost. Replacing $p_c(q)$ in the intermediary's profit function yields

$$r(q; \gamma) = \frac{\sigma}{C} \exp\left\{\frac{1}{\sigma}(\theta q - \sigma - p_s(q))\right\} - s(q, \gamma).$$

In the first stage, the intermediary chooses q to maximize the above expression. The first-order condition for this problem is given by

$$\frac{\partial p_s(q)}{\partial q} + \frac{\partial s(q, \gamma)}{\partial q} C / \exp\left\{\frac{1}{\sigma}(\theta q - \sigma - p_s(q))\right\} = \theta. \quad (10)$$

The left-hand side of the above equation denotes the increase in the cost to the intermediary of acquiring a good with marginally higher quality. This marginal cost consists of two components - the change in price paid by the intermediary to the producer and the change in the per unit screening cost. The right-hand side denotes the increase in revenue coming from the marginal unit, which is nothing but the marginal willingness to pay for higher quality. In equilibrium, the intermediary equates the marginal benefit of selling a higher quality variety with the associated marginal cost.³³

³³The $p_s(q)$ schedule is obtained from an underlying market clearing process where an intermediary with ability γ posts a price schedule $p_s(q; \gamma)$; this schedule gives the price that the intermediary is willing to pay to the home

The home exporter uses an intermediary for a single period.³⁴ The exporter takes the price schedule $p_s(q)$ as given and chooses what quality to produce. In doing so, he takes into account the optimal final price $p_c(q)$ charged by the intermediaries, because the amount sold to final consumers depends on $p_c(q)$. Exporter using intermediaries solve the following problem :

$$\max_q \pi^I(q; \lambda) = [p_s(q) - w(\bar{n} + e^{q-\lambda})] \frac{1}{C} \exp\left\{\frac{1}{\sigma}(\theta q - \sigma - p_s(q))\right\} + \frac{3\sigma}{C} \exp\left\{\frac{1}{\sigma}(\theta q - \sigma - w(\bar{n} + e^{q-\lambda}))\right\}$$

where we have replaced $p_c(q)$ with its optimal value from equation (9). Notice that the price charged by the exporter in the period two foreign market has the same functional form as in the last section. The first-order condition with respect to q is given by

$$\begin{aligned} & \left[\left(\frac{\partial p_s}{\partial q} - w e^{q-\lambda} \right) + (\theta - \frac{\partial p_s}{\partial q})(p_s(q) - w(\bar{n} + e^{q-\lambda})) \right] \exp\left\{\frac{1}{\sigma}(\theta q^I - \sigma - p_s(q^I))\right\} \\ & = 3(w e^{q^I-\lambda} - \theta) \exp\left\{\frac{1}{\sigma}(\theta q^I - \sigma - w(\bar{n} + e^{q^I-\lambda}))\right\} \quad (11) \end{aligned}$$

where q^I is the profit-maximizing quality when a firm chooses to use an intermediary in the first-period. The above equation implicitly defines q^I . The following lemma establishes some properties of q^I .

Lemma 4. q^I is increasing in λ and $q^I < q^D$.

Since the final price charged to the consumer, $p_c(q)$, includes the cost of screening quality, producing q^D while using intermediaries is not optimal any more. Of course, for any firm with capability λ , by how much q^I falls short of q^D will depend on which intermediary the firm matches with. As the next lemma shows, there is a monotonic relation between the ability of an intermediary and the quality of goods that it would like to sell.

Lemma 5. *Higher γ intermediaries sell higher quality goods.*

firms for each quality level. Observe that for an intermediary with ability γ , the $p_s(q; \gamma)$ schedules must be the iso-profit schedules. It can be shown that the iso-profit schedules are inverted U-shaped (See Appendix B for the proof). For low q , as q rises, the intermediary's revenue increases faster than the screening cost, holding $p_s(q; \gamma)$ constant. Naturally, $p_s(q; \gamma)$ must rise to keep the intermediary's profit unchanged. But for high levels of q , as q rises even further, the increase in screening costs dominate the increase in revenues and the intermediary remains indifferent by lowering $p_s(q; \gamma)$. Now, different intermediaries offer to pay different prices to the producers for each quality. In equilibrium, the intermediary offering the highest price for a particular quality is chosen to screen that quality, i.e., $p_s(q) = \max_{\gamma} p_s(q; \gamma)$. In other words, $p_s(q)$ is the upper envelope of the individual price schedules.

³⁴Ahn et al. (2010) provide evidence from Ghana where many firms start exporting through intermediaries but later transition into direct exporting.

The above result is a direct consequence of the cross-partials of the screening cost $s(q, \gamma)$. At the margin, a high γ intermediary face a smaller increase in cost of screening higher quality. This allows him to offer a higher price to the producer of higher quality compared to a low γ intermediary. The next lemma follows naturally from lemmas 4 and 5.

Lemma 6. *There is positive assortative matching (PAM) between λ and γ .*

Once a producer knows q^I , he chooses $\max\{\pi^D(q^D), \pi^X(q^X), \pi^I(q^I)\}$. Without imposing further restrictions on the parameter space, it is not possible to characterize the equilibrium any further. Therefore, as in the previous section, we focus our attention on a perfect sorting equilibrium, the difference being that now there is a third set - the set of exporters using intermediaries. Let us denote the exporters using intermediaries and those exporting directly by I exporters and X exporters respectively. As the following proposition shows, the existence of such an equilibrium depends on the ability of the most able intermediary ($\bar{\gamma}$) and the screening cost, $s(q, \gamma)$.

Proposition 3. *For a given range of firm capability $[\underline{\lambda}, \bar{\lambda}]$, there exists γ_{min} and γ_{max} such that for all $\gamma_{min} < \bar{\gamma} < \gamma_{max}$ and $\frac{\partial^2 s}{\partial^2 q}$ high enough, there exists a perfect sorting equilibrium where the most capable firms export directly while firms with intermediate levels of capability export through intermediaries.*

The above proposition says the following : $\exists \lambda_1, \lambda_2$ such that $\forall \lambda \in [\underline{\lambda}, \lambda_1]$ firms only sell domestically , $\forall \lambda \in [\lambda_1, \lambda_2]$ firms are I exporters while $\forall \lambda \in [\lambda_2, \bar{\lambda}]$ firms are X exporters. The structure of the equilibrium implies that the following conditions must be satisfied :

$$\begin{aligned}\pi^D(\lambda_1) &= \pi^I(\lambda_1), & \pi^I(\lambda_2) &= \pi^X(\lambda_1), \\ G(\lambda_2) - G(\lambda_1) &= 1 - F(\gamma^*), \\ \gamma^* &= \gamma(\lambda_1), & \bar{\gamma} &= \gamma(\lambda_2),\end{aligned}$$

where $\gamma(\lambda)$ is the equilibrium matching function between producers and intermediaries, and $\gamma^* \geq \underline{\gamma}$ is the intermediary with the lowest ability who can survive in the market. The requirement that $\bar{\gamma}$ lie in $[\gamma_{min}, \gamma_{max}]$ warrants some explanation. If $\bar{\gamma}$ is too high, the most capable exporter would choose to export through intermediaries. On the other hand, if $\bar{\gamma}$ is too low, none of the exporters might choose to use intermediaries. Note that in an equilibrium with intermediaries, the most able intermediary ($\bar{\gamma}$) will always operate since he can offer the highest price to producers of a given quality. Similarly, if $\frac{\partial^2 s}{\partial^2 q}$ is small, every exporter would find it profitable to use intermediaries. This can be seen on the left-hand side of equation 10. If marginal screening

cost, $\frac{\partial s(q,\gamma)}{\partial q}$, rises slowly, intermediaries would be willing to offer a higher price $p_s(q)$ to the producers.

5.2 Characterizing the equilibrium

A possible equilibrium configuration is shown in Figure 5. As displayed by the plot in the bottom half, there exists two discontinuities in quality as a function of capability. The fall in quality at λ_1 occurs because $q^I < q^D$ for all λ . On the other hand, if the screening cost rises fast enough with quality, quality jumps up at λ_2 . This counter-intuitive result arises because the use of intermediaries distorts the choice of quality by exporters. The most capable I exporters actually *pay* the intermediaries to signal their quality, i.e., for these producers, $p_s(q)$ is negative. Hence both I and X exporters incur a loss in the first period to signal their quality which ends up distorting their choice. For a given \bar{p} , the relative distortion depends on the rate of increase of $\frac{\partial s(q,\gamma)}{\partial q}$ with quality. Higher is $\frac{\partial s(q,\gamma)}{\partial q}$, more costly it is to sell high quality variety through the intermediary (See Appendix for the formal proof).

Notice how the cost of I exporters compares with that of X exporters. In the literature, intermediation is usually modeled as a technology that allows firms to export at a lower fixed cost but higher per unit costs relative to direct exporters. Our analysis provides a micro-foundation for such a technology. As discussed in the previous section, the fixed cost of exporting consists of two components - (a) cost of reputation and (b) opportunity cost of exporting. Although an I exporter still has to bear the opportunity cost (recall that $q^I < q^D$), it does not have to bear the reputation cost - the intermediary allows it to signal its quality perfectly. This results in a lower fixed cost of using intermediaries. On the other hand, there exists a set of exporters for whom $q^I < q^X$. Since the period two price in the foreign market is simply $\sigma + w(\bar{n} + e^{q-\lambda})$, if a firm chooses to be an I exporter rather than a X exporter, it suffers a discrete drop in price - this is an implicit per unit tax on the firm.

An endogenous intermediation sector also has implications for the period one final consumer price in the foreign market, $p_c(q)$, for products sold by I exporters. From equation 9 we know that $p_c(q) = \sigma + p_s(q)$. Assuming that $p_s(q)$ already includes the mark-up of the producer, equation 9 suggests that there is *double marginalization* - products sold through intermediaries are being “marked up” twice. This feature is also present in the model of [Ahn et al. \(2010\)](#). In their model, there is a complete pass-through of this extra markup of the intermediary to final prices. This is a consequence of CES preferences and the fact that intermediation is treated as a technology. In contrast, the price received by I exporters in our model is given by equation 10 which would typically not be constant across the exporters. Now consider the firms that

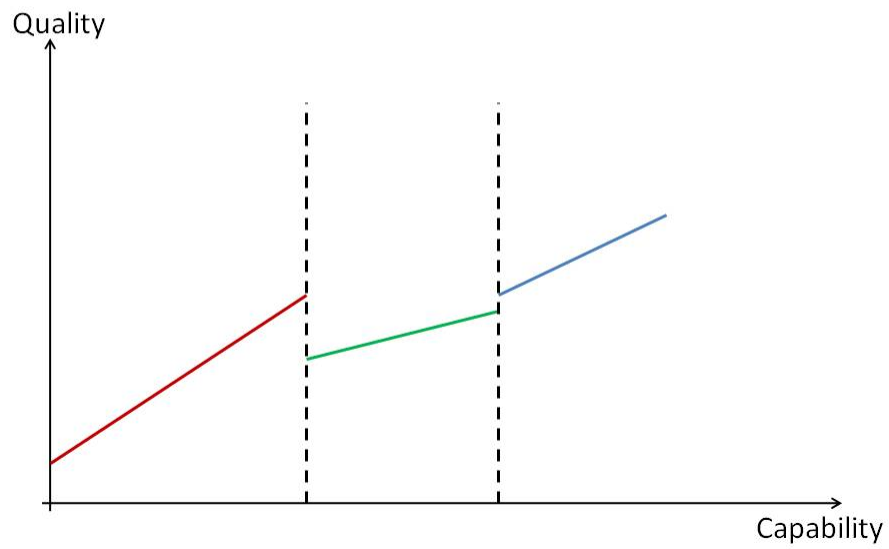
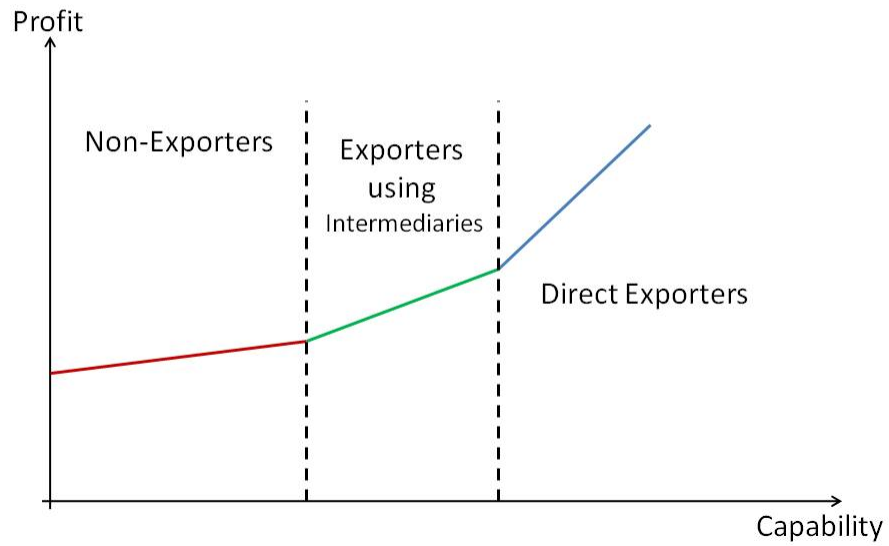


Figure 5: *Equilibrium profits and quality with intermediaries*

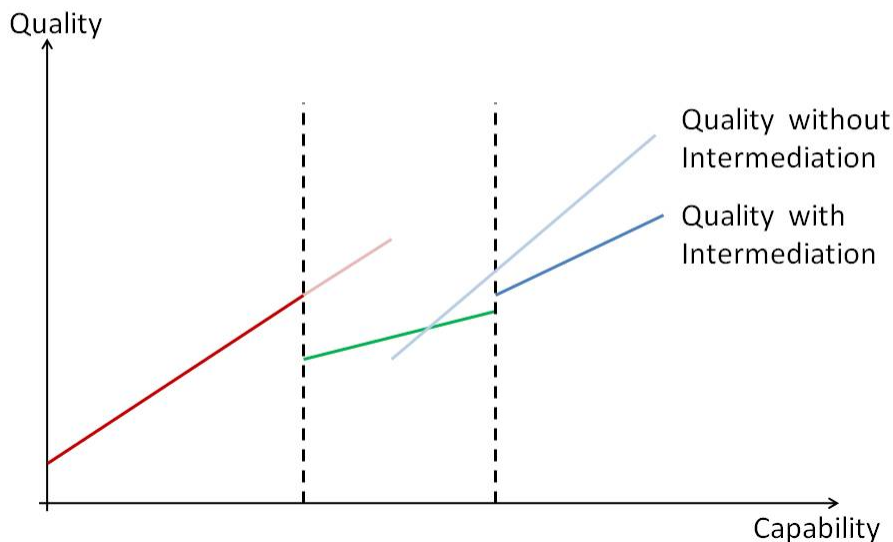


Figure 6: *Pre and post-intermediation quality*

switch from being domestic to exporting through intermediaries. For these firms, the price they were charging in the home market before they started exporting was $\sigma + \theta + w\bar{n}$ - a constant. Hence, the price received by the I exporters in the foreign market is different from what they were receiving in the home market before the switch - there is incomplete pass-through. Since this in turn affects the final price paid by consumers, our model has implications for welfare that may not be apparent if intermediation is treated as an exogenous technology.

The effect of intermediaries on the choice of quality is also interesting. This is shown in Figure 6. Among the firms that switch to using intermediaries, there are those who initially served only the home market and those that exported directly. The former set of firms experience a decline in quality for reasons already discussed. The latter set of firms, however, display heterogeneous response. Within this set, the less capable firms improve their quality whereas the more capable ones start producing lower quality goods. Therefore, the standard intuition that intermediaries, by allowing firms to signal their quality, would lead to improved quality is not necessarily true.

Figure 6 suggests that every firm that continues to be a X exporter experiences a drop in quality due to the introduction of intermediaries - there is an “externality”. To understand this result, note that we have held \bar{p} , the equilibrium price offered by foreign consumers to the X exporters, constant. On the other hand, consumers correctly anticipate that the least capable

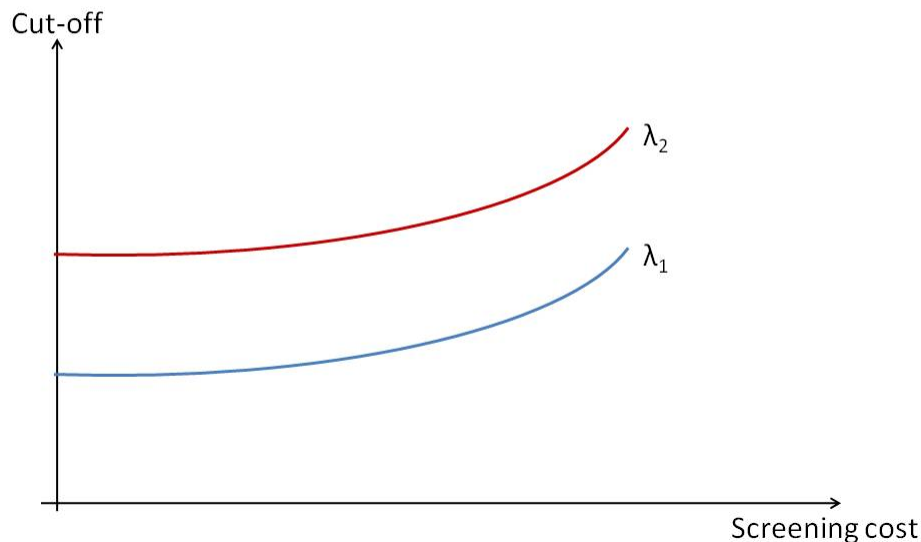


Figure 7: *Change in cut-offs with respect to screening cost*

among the X exporters switch to I exporters following the introduction of intermediaries. Consequently, the expected quality of X exporters, \bar{q} , goes up. This, in turn, raises the first period demand in the foreign market for varieties produced by the X exporters. With unchanged \bar{p} , per unit losses are higher, resulting in the X exporters to reduce quality. One might argue that as \bar{q} rises, so does \bar{p} ; after all, \bar{p} is determined on the basis of the foreign consumers' prior beliefs about quality of the home exporters. In such a case, whether the quality of X exporters rises or falls in the presence of intermediaries would depend on the elasticity of \bar{p} with respect to \bar{q} .

5.3 Comparative statics

Next, we perform some comparative statics with respect to efficiency of intermediation. The effectiveness of intermediation depends on two factors: the screening technology and the average ability of intermediaries. Figure 7 shows how the sorting of firms into different categories changes as the screening cost changes. As screening becomes cheaper, non-exporters switch to exporting through intermediaries (this follows from a decline in λ_1). On the other hand, counter to intuition, some of the I exporters switch to exporting directly (this follows from a decline in λ_2). A constant measure of intermediaries and one-to-one matching implies that there is a limited supply of intermediation service. With a fall in the screening cost, the demand for intermediaries rises. As $p_s(q)$ starts to fall, the most capable I exporters find it too costly to use

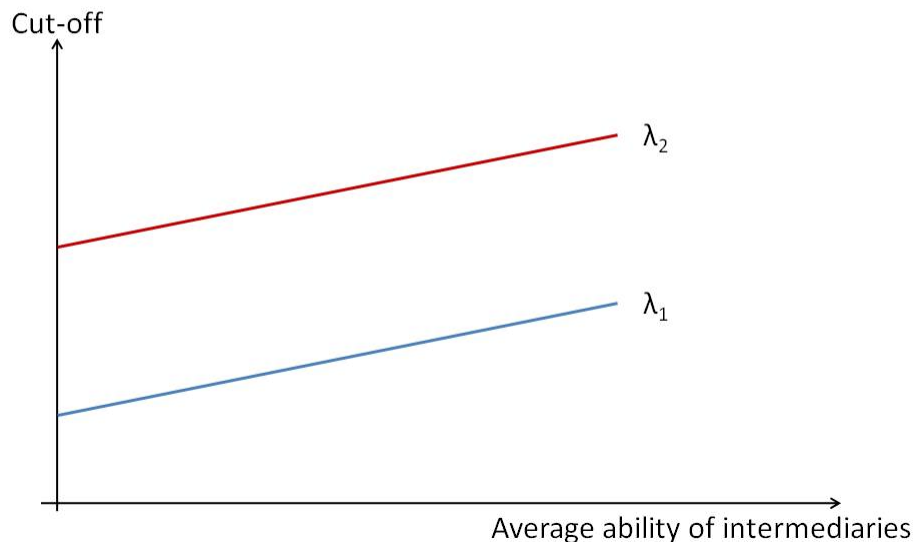


Figure 8: *Change in cut-offs with respect to average ability of intermediary*

intermediaries and switch into direct exporting.

Figure 8 shows how the sorting of firms into different categories changes as the average ability of intermediaries change. In terms of our analysis, we change the parameter that governs the expectation of the ability distribution $F(\gamma)$. As the average ability rises, λ_2 increases while λ_1 decreases. As the mass of more able intermediaries increases, competition among them is intensified. Since the more able intermediaries also buy high quality varieties, $p_s(q)$ rises for high q and falls for low q . The least capable among the X exporters now find it profitable to export through intermediaries instead. At the same time, some of the least capable I exporters find that exporting is not feasible any more; they stop exporting. Once again, one of the key assumptions driving this result is the fixed measure of intermediaries. Notice that although both lower screening costs and higher average intermediary ability are associated with improved intermediation technology, the effect on exporters is quite different depending on which of these parameters is changing. This is another instance of a case where an exogenous intermediation technology would have produced a different result.

The comparative static exercises are interesting in their own right. But they are also useful for analyzing how potential exporters might behave as they try to enter markets with different characteristics. For example, the screening cost could be a function of distance. If it is more costly to screen goods from countries that are more distant (perhaps because the intermediary

has to send an individual to the source country to inspect quality), the average capability of exporters will be higher in destination markets that are further away. Furthermore, the ratio of firms using intermediaries to firms who export directly will also be higher as the distance to the destination increases.³⁵ A similar pattern has been uncovered by [Ahn et al. \(2010\)](#) for firms exporting from China (although they look at intermediaries that operate in China, in contrast to this paper's focus on intermediaries in the export market).

6 Conclusion

In this paper, we have presented a framework to think about uncertainty about product quality in international trade. The basic assumption is that home consumers observe the quality of home goods perfectly, but foreign consumers do not. As a result, home firms have to establish reputation about their product in the foreign market. The fixed costs of exporting arise endogenously in our model due to reputation and the choice of sub-optimal quality in the home market. We go on to examine the role of trade intermediaries in such a setting and their effect on the choice of price, quality and exporting decision of firms. Trade intermediaries have a screening technology whereby they can reveal the true quality of a product. We establish the existence of an equilibrium where the most capable exporters export directly, while the less capable exporters export through intermediaries. In such an equilibrium, firms exporting through intermediaries face a lower fixed cost (they do not need to establish reputation) but have to pay a higher unit cost. We show that the consequences of introducing trade intermediaries are much more nuanced compared to what a model with exogenous intermediation technology suggests.

A key parameter of our model is \bar{p} , the pooled equilibrium price faced by home exporters in the first period foreign market. Throughout our analysis, we have remained agnostic about how \bar{p} is determined. If we believe that \bar{p} depends on the foreign consumers' perception of quality of home firms, then a negative perception, by lowering \bar{p} , can act as a significant barrier to entry in the export market. In fact, if the average capability of home firms is not too high to start with, a low enough \bar{p} could result in zero exports - even the most capable home firms would rather sell only at home than incur losses in trying to establish reputation in the foreign market; accordingly \bar{p} might remain unchanged or fall even more. Thus, our model suggests a path dependence in the exporting behavior of firms. This is an important theme that we hope to examine further in our future work.

³⁵This follows from the result that the mass of I exporters remains constant (because of one-to-one matching) while the mass of X exporters declines due to a rise in λ_2 .

Given that a large fraction of world trade is being carried out through intermediaries, it is important that we develop a good understanding of the intermediation sector. This will not only help us better understand the choices individual exporting firms make but also the pattern of trade at a more aggregate level. By affecting prices and quality, intermediaries could also have a large impact on welfare. Clearly, more work needs to be done.

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Appendix A

Proof of Lemma 1: Recall that $c(q^D(\lambda); \lambda) = \theta + wk \forall \lambda$. In particular, $c(q^D(\bar{\lambda}); \bar{\lambda}) = \theta + wk$. Therefore, if $\bar{p} > \theta + wk$, the least capable firm can earn a strictly positive profit in the Foreign market in period one by choosing quality $q^D(\bar{\lambda})$, which happens to be the optimal quality for the Home market. Since profit from exporting in period two is always positive, the least capable firm will always choose to export, violating our condition for a perfect sorting equilibrium.

Proof of Lemma 2: We shall prove the lemma by contradiction. Suppose the off-equilibrium belief is $\mu(q = q' | p > \bar{p}) = 1$ where $q' > -\infty$. Choose the firm with capability $\bar{\lambda}$. Since $\bar{p} < c(q^X(\bar{\lambda}); \bar{\lambda})$, this firm is incurring a loss in period one. The firm can choose $p = c(q^X(\bar{\lambda}); \bar{\lambda}) + \epsilon$. Then it earns positive profit per unit while facing a positive demand (since $q' > -\infty$). Hence, this is a profitable deviation.

Proof of Lemma 3: First consider $\bar{p} \rightarrow c(q^X(\bar{\lambda}); \bar{\lambda})$. Suppose $\mu(q = q' | p < \bar{p}) = 1$ where $q' > \bar{q}$. We can always find an exporter with λ such that $\bar{p} > c(q^X(\lambda); \lambda)$. This exporter could charge $p = \bar{p} - \epsilon$. His profits per unit would remain almost unchanged while quantity demanded would increase discretely. Therefore he has a profitable deviation. On the other hand, suppose $\mu(q = q' | p < \bar{p}) = 1$ where $q' < \bar{q}$. Then the exporter with capability $\bar{\lambda}$ can charge a price slightly lower than \bar{p} and reduce his losses. Hence this cannot be an equilibrium either.

Instead, if $\bar{p} \rightarrow wk$, then every exporter is making a loss in period one. Any downward deviation in price increases per unit losses and raises demand if $\mu(q = q_H | p < \bar{p}) = 1$. Therefore, $p < \bar{p}$ is not a profitable deviation.

Proof of Proposition 1: We shall use the intermediate value theorem to prove part (i). We shall also prove the result for $\bar{n} \rightarrow 0$. Then, by continuity, the result will go through for \bar{n} small enough. We proceed in steps. First, we find the conditions under which $\frac{\partial \pi^X(\lambda)}{\partial \lambda} \geq \frac{\partial \pi^D(\lambda)}{\partial \lambda} \forall \lambda$. Second, we find the conditions under which $\pi^X(\lambda) < \pi^D(\lambda)$ for $\lambda = 0$. And finally, we find the conditions under which $\pi^X(\lambda) > \pi^D(\lambda)$ for $\lambda \rightarrow \bar{\lambda}$.

Step 1: From (5), the slope of π^D can be calculated as

$$\frac{\partial \pi^D(\lambda)}{\partial \lambda} = \frac{2\theta}{C} \exp\left\{\frac{1}{\sigma}(\theta\lambda + \theta \log \frac{\theta}{w} - \sigma - \theta)\right\}.$$

The slope of π^X can be calculated from (6) as

$$\frac{\partial \pi^X(\lambda)}{\partial \lambda} = w \exp\left\{q - \lambda + \frac{\theta\bar{q}}{\sigma}\right\} + \frac{3\sigma}{C} \exp\left\{\frac{1}{\sigma}(\theta q - \sigma - we^{q-\lambda})\right\} \left(\frac{1}{\sigma} we^{q-\lambda}\right).$$

Substituting from the first-order condition and a bit of algebra yields

$$\frac{\partial \pi^X(\lambda)}{\partial \lambda} = \exp\left\{\frac{\theta\bar{q}}{\sigma}\right\} \frac{\theta}{\frac{\theta}{we^{q-\lambda}} - 1}.$$

Therefore, for π^X to be steeper than π^D for all values of λ , we need the following :

$$\frac{2}{C.exp\{\frac{\theta\bar{q}}{\sigma}\}} \left(\frac{\theta}{we^{q^X-\lambda}} - 1 \right) exp\left\{ \frac{1}{\sigma} (\theta\lambda + \theta \log \frac{\theta}{w} - \sigma - \theta) \right\} \leq 1$$

A sufficient condition for the above inequality to be satisfied is that

$$2 \left(\frac{\theta}{we^{q^X-\lambda}} - 1 \right) \leq 1 \quad (\text{A1})$$

and

$$\frac{1}{C.exp\{\frac{\theta\bar{q}}{\sigma}\}} exp\left\{ \frac{1}{\sigma} (\theta\lambda + \theta \log \frac{\theta}{w} - \sigma - \theta) \right\} \leq 1 \quad (\text{A2})$$

Inequality (A1) can be re-written as

$$q^X - \lambda \geq \log\left(\frac{2\theta}{3w}\right)$$

Now, the LHS of the above inequality is increasing in λ (to be shown). Hence, if we can show that this inequality holds for $q^X(0)$, we are done. For $q^X(0)$ to be greater than $\log(\frac{2\theta}{3w})$, we must have $\frac{\partial \pi^X(0)}{\partial \lambda} > 0$ when $q = \log(\frac{2\theta}{3w})$. Now,

$$\frac{\partial \pi^X(0)}{\partial \lambda} \Big|_{q=\log(\frac{2\theta}{3w})} = \frac{\theta}{3} \left[\frac{3}{C} exp\left\{ \frac{1}{\sigma} \left(\theta \log\left(\frac{2\theta}{3w}\right) - \frac{2\theta}{3} \right) - 1 \right\} - 2 exp\left\{ \frac{\theta\bar{q}}{\sigma} \right\} \right]$$

The above expression can be made positive by choosing σ small enough, as long as $\theta \log(\frac{2\theta}{3w}) - \frac{2\theta}{3} > 0$. The required condition is

$$\theta > \frac{3}{2} we^{\frac{2}{3}} \quad (\text{A3})$$

Inequality (A2) can be re-written as

$$exp\left\{ \frac{1}{\sigma} (\theta\lambda + \theta \log \frac{\theta}{w} - \sigma - \theta) \right\} \leq C.exp\left\{ \frac{\theta\bar{q}}{\sigma} \right\} \quad (\text{A4})$$

The above inequality essentially puts an upper bound on $\bar{\lambda}$. Therefore, as long as (A3) is satisfied and $\bar{\lambda}$ is such that (A4) is satisfied, $\frac{\partial \pi^X(\lambda)}{\partial \lambda} \geq \frac{\partial \pi^D(\lambda)}{\partial \lambda} \forall \lambda$.

Step 2: We shall proceed by deriving the condition under which $\pi^X(0, q^X(0)) < \pi^D(0, q^X(0))$. Then the above inequality follows. We first show that if $\theta < \frac{3}{2}$, $q^X - \lambda$ is increasing in λ . Defining $q^X - \lambda$ as Φ and replacing in (7), we have

$$we^\Phi exp\left\{ \frac{\theta\bar{q}}{\sigma} \right\} = \frac{3\sigma}{C} exp\left\{ \frac{1}{\sigma} (\theta\Phi + \theta\lambda - \sigma - we^\Phi) \right\} \left[\frac{1}{\sigma} (\theta - we^\Phi) \right].$$

Differentiating w.r.t. λ and collecting terms,

$$\left[we^\Phi exp\left\{ \frac{\theta\bar{q}}{\sigma} \right\} + \frac{3}{C} R(we^\Phi - \frac{1}{\sigma} (\theta - we^\Phi)^2) \right] \frac{d\Phi}{d\lambda} = \frac{3}{\sigma C} R\theta(\theta - we^\Phi)$$

where $R = \exp\{\frac{1}{\sigma}(\theta\Phi + \theta\lambda - \sigma - we^\Phi)\}$. For $\frac{d\Phi}{d\lambda}$ to be positive, we need

$$\theta^2 < [(2\theta + \mu) - we^\Phi]we^\Phi$$

for all λ . Now, $(2\theta + \sigma) - we^\Phi > 0$ because $we^\Phi < we^{q^D - \lambda} < \theta$. Hence, if Φ is increasing in λ and the above expression holds for $\lambda = 0$, then we are done. Because $\sigma > \theta$, we know that,

$$[(2\theta + \sigma) - we^\Phi]we^\Phi > \theta^2 we^\Phi$$

Hence, if $we^\Phi > 1$ for $\lambda = 0$, then we are done. In order for this to be true, we need $q^X(0) > \log(\frac{1}{w})$. We have already derived the condition under which $q^X(0) > \log(\frac{2\theta}{3w})$. Hence, if $\theta < \frac{3}{2}$, our claim that $q^X - \lambda$ is increasing in λ is true. Now, from (5) and (6), we get the following:

$$\pi^D(0, q^X(0)) = \frac{2\sigma}{3} \exp\left\{\frac{\theta\bar{q}}{\sigma}\right\} \frac{we^{q^X(0)}}{\theta - we^{q^X(0)}}.$$

and

$$\pi^X(0, q^X(0)) = we^{q^X(0)} \exp\left\{\frac{\theta\bar{q}}{\sigma}\right\} \left(\frac{\sigma}{\theta - we^{q^X(0)}} - 1\right).$$

For $\pi^D(0, q^X(0)) > \pi^X(0, q^X(0))$, we need the following:

$$3(\theta - we^{q^X(0)}) > \sigma$$

If we can find an upper bound for $q^X(0)$, then we have a condition. Let this upper bound be 0. For this to be true, $\frac{\partial \pi^X(0, q^X)}{\partial q^X}$ must be negative at $q^X = 0$. The corresponding condition is

$$\frac{1}{\exp\{1 + \frac{w}{\sigma}\}} \left(\frac{\theta}{w} - 1\right) < \frac{C}{3} \exp\left\{\frac{\theta\bar{q}}{\sigma}\right\}$$

The above condition holds for σ small enough. Hence, for σ small, $e^{q^X(0)} < 1$. Then, for the boundary condition to be satisfied, we must have

$$3(\theta - w) > \sigma \tag{A5}$$

Step 3: Conditions under which $\pi^X(\lambda) > \pi^D(\lambda)$ for λ large enough. We shall show this by deriving the condition under which there exists a λ such that $\pi^X(\lambda, q^D(\lambda)) > \pi^D(\lambda, q^X(\lambda))$. Then the above inequality follows. From (5) and (6), we get the following:

$$\begin{aligned} \pi^X(\lambda, q^D(\lambda)) &= -w \frac{\theta}{w} \exp\left\{\frac{\theta\bar{q}}{\sigma}\right\} + \frac{3\sigma}{C} \exp\left\{\frac{1}{\sigma}(\theta\lambda - \theta \log \frac{\theta}{w} - \sigma - \theta)\right\}. \\ \pi^D(\lambda, q^D(\lambda)) &= \frac{2\sigma}{C} \exp\left\{\frac{1}{\sigma}(\theta\lambda + \theta \log \frac{\theta}{w} - \sigma - \theta)\right\}. \end{aligned}$$

Hence, the required condition is

$$\exp\left\{\frac{1}{\sigma}(\theta\lambda + \theta \log \frac{\theta}{w} - \sigma - \theta)\right\} > \frac{\theta C}{\sigma} \exp\left\{\frac{\theta\bar{q}}{\sigma}\right\}. \tag{A6}$$

Since the LHS of the above expression is increasing in λ , there exists a λ for which the above inequality

holds. Suppose $\bar{\lambda}$ is such that (A6) holds. But we know that $\bar{\lambda}$ must also satisfy (A5). Such a $\bar{\lambda}$ would exist if $1 > \frac{\theta}{\sigma}$, which we assume is true. We can summarize conditions (A3) and (A4) as

$$3(1 - \frac{2}{3}e^{-\frac{2}{3}})\theta > 3(\frac{3}{2}e^{\frac{2}{3}} - 1)w > \sigma > \theta.$$

In order to prove part (ii), we note that the result that q^D is increasing in λ follows from equation 4. To see that q^X is also increasing in λ , differentiate equation 7 with respect to λ . Collecting terms, we have

$$[(1 - \frac{\theta}{\mu}) + we^{q^X - \lambda}(\frac{1}{\sigma} + \frac{1}{\theta - we^{q^X - \lambda}})]\frac{dq^X}{d\lambda} = 1 + we^{q^X - \lambda}(\frac{1}{\sigma} + \frac{1}{\theta - we^{q^X - \lambda}})$$

As proved later, $q^D > q^X$. Therefore, $\theta = we^{q^D - \lambda} > we^{q^X - \lambda}$. So, if $\theta < \sigma$, $\frac{dq^X}{d\lambda} > 0$. Differentiating the profit function with respect to q and evaluating the derivative at $q = q^D$,

$$\begin{aligned} \frac{\partial \pi^X(\lambda)}{\partial q} \Big|_{q=q^D} &= -w \cdot \exp\{q^D - \lambda + \frac{1}{\sigma}(\theta \bar{q} - \bar{p})\} \\ &< 0 \end{aligned}$$

Therefore, the profit-maximizing quality under exporting, q^X , must be less than q^D .

Proof of Proposition 2: We have shown that there is a one-to-one relation between λ and sales, $r(\lambda)$. Hence we shall prove the result for capability quantiles in stead of size quantiles. We proceed in steps.

Step 1: The j -th p-quantile is defined as $\int_{\lambda_j}^{\lambda_{j+1}} dG(\lambda) = p$. If $G(\lambda)$ is truncated Pareto with shape parameter κ , then

$$\int_{\lambda_j}^{\lambda_{j+1}} dG(\lambda) = \Gamma[(\frac{1}{\lambda_j})^\kappa - (\frac{1}{\lambda_{j+1}})^\kappa],$$

where Γ is some constant. Suppose $\lambda_{j+1} = \lambda_j + h$, where h is a constant. Then $\frac{d}{d\lambda_j} \Gamma[(\frac{1}{\lambda_j})^\kappa - (\frac{1}{\lambda_{j+1}})^\kappa] < 0$. Hence, h must rise as λ_j increases. Accordingly, let us define $\lambda_{j+1} - \lambda_j = h(\lambda_j)$, $h' > 0$.

Step 2: In equilibrium, it must be the case that for $\lambda \rightarrow_+ \lambda^X$, $r(q^X; \lambda) < r(q^D; \lambda)$. We shall prove this by contradiction. Suppose not. We know that for λ close to but greater than λ^x , $\pi(q^X; \lambda) < \pi(q^D; \lambda)$ (since q^X is the profit-maximizing quality). Therefore, if $r(q^X; \lambda) > r(q^D; \lambda)$, it must be the case that $c(q^X; \lambda) > c(q^D; \lambda)$ so that $r(q^X; \lambda) - c(q^X; \lambda) < r(q^D; \lambda) - c(q^D; \lambda)$, i.e., we must have $d(\frac{r(q; \lambda)}{c(q; \lambda)})/dq > 0$. Now,

$$\begin{aligned} \frac{r(q; \lambda)}{c(q; \lambda)} &= \frac{\sigma + w(e^{q^D - \lambda} + \bar{n})}{w(e^{q^D - \lambda} + \bar{n})} \\ &= 1 + \frac{\sigma}{w(e^{q^D - \lambda} + \bar{n})} \end{aligned}$$

It is clear that as q rises, $\frac{r(q; \lambda)}{c(q; \lambda)}$ falls; we have a contradiction.

Step 3: From Step 2 it is clear that there is an overlap in the Home sales between young exporters and non-exporters. But the exporters also earn revenues from the Foreign market. These revenues are directly proportional to \bar{p} and can be made as small as possible. As a result, we can get an overlap in total sales between young exporters and non-exporters. Now, for the full information case, we have $r^D(\lambda) = K \exp\{\frac{\theta}{\sigma}\lambda\}$, where K is some constant and r^D is the sales of a firm that sells only in the Home market. We hypothesize that the Home sales of an exporter, r^X , can be similarly written as $r^X(\lambda) = K' \exp\{\frac{\theta}{\sigma}\lambda\}$. Pick the capability of a non-exporter. Let us call this λ^D . Pick the corresponding capability level for the exporter, λ^X , such that $r^D(\lambda^D) = r^X(\lambda^X)$. Then it is easy to show that $\lambda^X = \lambda^D + \phi$. From Step 1, we know that $\lambda_{j+1} = \lambda_j + h(\lambda_j)$. Let us define,

$$\lambda_{j+1}^i = \lambda_j^i + h^i(\lambda_j^i), i = D, X$$

where the subscript i on the function $h(\cdot)$ allows for the function to be different for exporters and non-exporters. Combining this with our previous observation, we have

$$\begin{aligned}\lambda_{j+1}^D &= \lambda_j^D + h^D(\lambda_j^D) \\ \lambda_j^X &= \lambda_j^D + \phi \\ \lambda_{j+1}^X &= \lambda_j^X + h^X(\lambda_j^X) \\ &= \lambda_j^D + \phi + h^X(\lambda_j^D + \phi)\end{aligned}$$

For any size quantile, the fraction of exporters to non-exporters is then given by

$$\xi_j = \frac{(\frac{1}{\lambda_j^D + \phi})^\kappa - (\frac{1}{\lambda_j^D + \phi + h^X(\lambda_j^D + \phi)})^\kappa}{(\frac{1}{\lambda_j^D})^\kappa - (\frac{1}{\lambda_j^D + h^D(\lambda_j^D)})^\kappa}$$

We are interested in how ξ_j changes as λ_j^D increases. Differentiating ξ_j with respect to λ_j^D , and ignoring a positive constant, we have

$$\begin{aligned}\frac{d\xi_j}{d\lambda_j^D} &= [- (\frac{1}{\lambda_j^D + \phi})^{\kappa+1} + (\frac{1}{\lambda_j^D + \phi + h^X(\lambda_j^D + \phi)})^{\kappa+1} (1 + \frac{\partial h^X}{\partial \lambda})] [(\frac{1}{\lambda_j^D})^\kappa - (\frac{1}{\lambda_j^D + h^D(\lambda_j^D)})^\kappa] \\ &\quad - [- (\frac{1}{\lambda_j^D})^{\kappa+1} + (\frac{1}{\lambda_j^D + h^D(\lambda_j^D)})^{\kappa+1} (1 + \frac{\partial h^D}{\partial \lambda})] [(\frac{1}{\lambda_j^D + \phi})^\kappa - (\frac{1}{\lambda_j^D + \phi + h^X(\lambda_j^D + \phi)})^\kappa]\end{aligned}$$

Suppose $\frac{\partial h^D}{\partial \lambda}$ and $\frac{\partial h^X}{\partial \lambda}$ are small. Then we can ignore these values. Taking Taylor series expansion around $h^D = 0$,

$$(\frac{1}{\lambda_j^D + h^D})^\kappa = (\frac{1}{\lambda_j^D})^\kappa - \kappa (\frac{1}{\lambda_j^D})^{\kappa+1} h^D$$

Taking Taylor series expansion around $h^X = 0$, we have

$$(\frac{1}{\lambda_j^D + \phi + h^X})^\kappa = (\frac{1}{\lambda_j^D + \phi})^\kappa - \kappa (\frac{1}{\lambda_j^D + \phi})^{\kappa+1} h^X$$

Similarly, we have

$$\left(\frac{1}{\lambda_j^D + h^D}\right)^{\kappa+1} = \left(\frac{1}{\lambda_j^D}\right)^{\kappa+1} - (\kappa+1)\left(\frac{1}{\lambda_j^D}\right)^{\kappa+2}h^D$$

and

$$\left(\frac{1}{\lambda_j^D + \phi + h^X}\right)^{\kappa+1} = \left(\frac{1}{\lambda_j^D + \phi}\right)^{\kappa+1} - (\kappa+1)\left(\frac{1}{\lambda_j^D + \phi}\right)^{\kappa+2}h^X$$

Replacing the above values in the expression for $\frac{d\xi_j}{d\lambda_j^D}$ and again ignoring a positive constant, we have

$$\begin{aligned} \frac{d\xi_j}{d\lambda_j^D} &= \kappa^2(\kappa+1)h^Dh^X\left(\frac{1}{\lambda_j^D + \phi}\right)^{\kappa+1}\left(\frac{1}{\lambda_j^D}\right)^{\kappa+1}\left(-\frac{1}{\lambda_j^D + \phi} + \frac{1}{\lambda_j^D}\right) \\ &> 0 \end{aligned}$$

where the second line follows from the fact that $\frac{1}{\lambda_j^D + \phi} < \frac{1}{\lambda_j^D}$. Therefore, the share of exporters to non-exporters is increasing in capability and hence, size quantiles.

Appendix B

Proof of $p_s(q; \gamma)$ being inverted U-shaped: From the intermediary's first-order condition (10),

$$\frac{\partial p_s}{\partial q} = \theta - \frac{\partial s(q, \gamma)}{\partial q} C / \exp\left\{\frac{1}{\sigma}(\theta q - \sigma - p_s(q; \gamma))\right\}.$$

As q and $p_s(q; \gamma)$ increase, there are three effects on $\frac{\partial p_s}{\partial q}$. First, $\frac{\partial s(q, \gamma)}{\partial q}$ increases, which tends to reduce $\frac{\partial p_s}{\partial q}$. Second, the increase in $p_s(q; \gamma)$ tends to reduce $\frac{\partial p_s}{\partial q}$. And finally, the increase in q tends to increase $\frac{\partial p_s}{\partial q}$. A sufficient condition for $\frac{\partial p_s}{\partial q}$ to decrease with q is that $\frac{\partial s(q, \gamma)}{\partial q}$ increases at a rate greater than $\frac{\theta}{\sigma}$, the latter being the rate at which the denominator of the second term on the right-hand side of the above expression increases with q . Therefore, as long as $p_s(q; \gamma)$ is increasing, $\frac{\partial p_s}{\partial q}$ is falling. Furthermore, if $\frac{\partial s(q, \gamma)}{\partial q} \rightarrow 0$ as $q \rightarrow 0$, then $\frac{\partial p_s}{\partial q} > 0$. Hence, there exists an interval of q over which $p_s(q; \gamma)$ is increasing.

We also need to prove that $\frac{\partial p_s}{\partial q}$ does not become positive for high enough q , i.e. we need to prove that $p_c(q; \gamma)$ is quadratic. Suppose not. Then we can find q_1, q_2, q_3 such that $p_s(q_1; \gamma) = p_s(q_2; \gamma) = p_s(q_3; \gamma)$ and $\frac{\partial p_s}{\partial q}|_q = q_1 > 0$, $\frac{\partial p_s}{\partial q}|_q = q_2 < 0$, $\frac{\partial p_s}{\partial q}|_q = q_3 > 0$. Now, the only thing that changes between q_2 and q_3 is that quality is higher at q_3 with no corresponding change in price. Given our earlier assumption about the rate of change of $\frac{\partial s(q, \gamma)}{\partial q}$ with q , this means that $\frac{\partial s(q, \gamma)}{\partial q}|_{q=q_3} < \frac{\partial s(q, \gamma)}{\partial q}|_{q=q_2}$ - a contradiction.

Proof of Lemma 4: The slope of π^I at $q = q^D$ satisfies

$$\frac{\partial \pi^I}{\partial q}|_{q=q^D} = \frac{\partial s}{\partial q} \left(\frac{1}{\sigma} (p_s(q^D) - \theta) - 1 \right) \quad (\text{A7})$$

For the first part, observe that for a given quality q , the price that maximizes final profits is $\sigma + we^{q^I - \lambda}$. When $q = q^D$, this price becomes $\sigma + \theta$. When there are intermediaries, this price must be divided between the intermediary and the firm. Given that the intermediary bears a positive cost $s(q, \gamma)$, he must

get a positive share of the price. Otherwise he will make losses and exit. Hence, we must have

$$p_s(q^D) < \sigma + \theta.$$

Re-arranging, this becomes

$$\frac{1}{\sigma}(p_s(q^D) - \theta) < 1.$$

Replacing the above expression in (A7) we have $\frac{\partial \pi^I}{\partial q}|_{q=q^D} < 0$. Therefore, $q^I < q^D$.

For the second part, differentiate the firm's first-order condition (11) with respect to λ to get

$$\begin{aligned} \frac{dq}{d\lambda} & \left[\frac{1}{\theta - \frac{\partial p_s}{\partial q}} \left(\left(\frac{\partial^2 p_s}{\partial^2 q} - we^{q^I-\lambda} \right) \left(\theta - \frac{\partial p_s}{\partial q} \right) \frac{\partial s}{\partial q} + \left(\theta - \frac{\partial p_s}{\partial q} \right) \left(\frac{\partial p_s}{\partial q} - we^{q^I-\lambda} \right) \frac{\partial^2 s}{\partial^2 q} + \left(\frac{\partial p_s}{\partial q} - we^{q^I-\lambda} \right) \frac{\partial s}{\partial q} \frac{\partial^2 p_s}{\partial^2 q} \right) \right. \\ & \left. + \frac{1}{\sigma} \left(\frac{\partial p_s}{\partial q} - we^{q^I-\lambda} \right) \left(\frac{\partial s}{\partial q} + \frac{\partial^2 s}{\partial^2 q} \right) - 3 \exp \left\{ \frac{1}{\sigma} (\theta q^I - \sigma - we^{q^I-\lambda}) \right\} \left(we^{q^I-\lambda} - \frac{1}{\sigma} (\theta - we^{q^I-\lambda})^2 \right) \right] \\ & = -we^{q^I-\lambda} \frac{\partial s}{\partial q} \left(\frac{1}{\theta - \frac{\partial p_s}{\partial q}} + \frac{1}{\sigma} \right) - 3 \exp \left\{ \frac{1}{\sigma} (\theta q^I - \sigma - we^{q^I-\lambda}) \right\} \frac{we^{q^I-\lambda}}{\sigma} (\theta - we^{q^I-\lambda}) \end{aligned}$$

The right-hand side of the above equation is negative ($\because \theta - \frac{\partial p_s}{\partial q} > 0$ from (10) and $\theta - we^{q^I-\lambda} > 0$).

Therefore if $\frac{dq}{d\lambda} > 0$, the expression within brackets on the left-hand side must be negative too. Then it is easy to check that the second-order condition of the firm's profit-maximization problem will be satisfied. Hence, higher λ firms must produce higher quality varieties.

Proof of Lemma 5: Totally differentiating the intermediary's first-order condition (10), we have

$$\left[A \frac{1}{\sigma} \left(\theta - \frac{\partial p_s}{\partial q} \right)^2 - \frac{\partial^2 s}{\partial^2 q} + A \left(- \frac{\partial^2 p_s}{\partial^2 q} \right) \right] dq = \frac{\partial^2 s}{\partial q \partial \gamma} d\gamma$$

where $A = \exp \left\{ \frac{1}{\sigma} (\theta q - \sigma - p_s(q)) \right\}$. By assumption, $\frac{\partial^2 s}{\partial q \partial \gamma} < 0$. Therefore, if $\frac{dq}{d\lambda} > 0$, the expression within the brackets on the left-hand side must be negative. It is easy to check that this implies that the second-order condition of the intermediary's profit-maximization problem is satisfied. Hence, we must have $\frac{dq}{d\lambda} > 0$.

Proof of Proposition 3: After totally differentiating the firm's first-order condition and collecting terms involving $\frac{\partial^2 s}{\partial^2 q}$, it can be shown that $\frac{dq}{d\lambda}$ is an increasing function of $\left(\frac{\frac{\partial p_s}{\partial q} - we^{q^I-\lambda}}{\theta - \frac{\partial p_s}{\partial q}} + \frac{p_s - we^{q^I-\lambda}}{\sigma} \right) \frac{\partial^2 s}{\partial^2 q}$. Now, there exists $\bar{\gamma}$ such that for q high enough, $\frac{\partial p_s}{\partial q} < we^{q^I-\lambda}$ and $p_s < we^{q^I-\lambda}$ (this follows from equation 10). Then $\frac{dq}{d\lambda}$ can be made as small as possible by choosing a large enough $\frac{\partial^2 s}{\partial^2 q}$. Differentiating the equilibrium profit of the X exporter with respect to λ ,

$$\frac{\partial \pi^I}{\partial \lambda} = we^{q^I-\lambda} \frac{1}{C} \exp \left\{ \frac{1}{\sigma} (\theta q^I - \sigma - p_s(q)) \right\} + 3\sigma \frac{1}{C} \exp \left\{ \frac{1}{\sigma} (\theta q^I - \sigma - w(\bar{n} + e^{q^I-\lambda})) \right\} we^{q^I-\lambda}.$$

Taking partial differentiation again with respect to λ ,

$$\frac{\partial^2 \pi^I}{\partial^2 \lambda} = we^{q^I - \lambda} \frac{1}{C} [-exp\{\frac{1}{\sigma}(\theta q^I - \sigma - p_s(q))\} + 3exp\{\frac{1}{\sigma}(\theta q^I - \sigma - w(\bar{n} + e^{q^I - \lambda}))\}(\frac{we^{q^I - \lambda}}{\sigma} - 1)].$$

But $\frac{we^{q^I - \lambda}}{\sigma} < \frac{we^{q^I - \lambda}}{\sigma} < 1$. Hence, the second term in the above expression is negative and $\frac{\partial^2 \pi^I}{\partial^2 \lambda} < 0$. Also, note that $\frac{d\pi^I}{d\lambda} = \frac{\partial \pi^I}{\partial q} \frac{dq}{d\lambda} + \frac{\partial \pi^I}{\partial \lambda} = \frac{\partial \pi^I}{\partial \lambda}$. This follows from the fact that $\frac{\partial \pi^I}{\partial q} = 0$ in equilibrium. Therefore, taking the double derivative of π^I with respect to λ , we have

$$\begin{aligned} \frac{d^2 \pi^I}{d^2 \lambda} &= \frac{d}{d\lambda} \left(\frac{\partial \pi^I}{\partial \lambda} \right) \\ &= \frac{\partial}{\partial q} \left(\frac{\partial \pi^I}{\partial \lambda} \right) \frac{dq}{d\lambda} + \frac{\partial^2 \pi^I}{\partial^2 \lambda} \end{aligned}$$

Therefore, $\frac{d^2 \pi^I}{d^2 \lambda} < 0$ if $\frac{dq}{d\lambda}$ is small enough. It is straightforward to show that this ensures that there exists a $\hat{\lambda}$ such that $\pi^I(\lambda) > \pi^X(\lambda)$ for $\lambda < \hat{\lambda}$ while $\pi^I(\lambda) < \pi^X(\lambda)$ for $\lambda > \hat{\lambda}$.

Proof that if the cost of screening increases sharply with quality, $q^I < q^X$ for $\lambda = \lambda_2$: Differentiating π^I with respect to q and evaluating at $q = q^X$, we have

$$\begin{aligned} \frac{\partial \pi^I}{\partial q} |_{q=q^X} &= \left[\left(\frac{\partial p_s}{\partial q} - we^{q^X - \lambda} \right) + \left(\theta - \frac{\partial p_s}{\partial q} \right) (p_s(q^X) - w(\bar{n} + e^{q^X - \lambda})) \right] exp\left\{ \frac{1}{\sigma} (\theta q^X - \sigma - p_s(q^X)) \right\} \\ &\quad + 3(\theta - we^{q^X - \lambda}) exp\left\{ \frac{1}{\sigma} (\theta q^X - \sigma - w(\bar{n} + e^{q^X - \lambda})) \right\}. \end{aligned} \quad (\text{A8})$$

The second term on the right-hand side of the above equation is always positive. But it is a constant for $\lambda = \lambda_2$ and q^X . Now, we can choose $\bar{\gamma}$ such that $p_s(q^X) < w(\bar{n} + e^{q^X - \lambda})$. This follows from the result that the producer with capability λ_2 matches with the intermediary with ability $\bar{\gamma}$ and that $p_s(q; \gamma)$ is inverted U-shaped. Also from the intermediary's first-order condition (10),

$$\frac{\partial p_s}{\partial q} = \theta - \frac{\partial s(q, \gamma)}{\partial q} C / exp\left\{ \frac{1}{\sigma} (\theta q - \sigma - p_s(q)) \right\}.$$

Note that we can make $\frac{\partial p_s}{\partial q}$ as small as possible by choosing a high enough $\frac{\partial s(q, \gamma)}{\partial q}$. Hence, if $\frac{\partial p_s}{\partial q}$ is large enough, the first term on the right-hand side of (A8) becomes negative and can dominate the second term, whereby $\frac{\partial \pi^I}{\partial q} |_{q=q^X} < 0$.