Market size, Competition, and the Product Mix of Exporters*

Thierry Mayer
Paris School of Economics, Université Paris I
CEPII and CEPR

Marc J. Melitz
Princeton University
NBER and CEPR

Gianmarco I.P. Ottaviano
Bocconi University
FEEM and CEPR

June 22, 2009

PRELIMINARY AND INCOMPLETE DRAFT
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*We thank Steve Redding for help comments and suggestions. Ottaviano thanks MIUR and the European Commission for financial support. Melitz thanks the Sloan Foundation for financial support.

1 Introduction

Recent empirical evidence has highlighted how the export patterns of multi-product firms dominate world trade flows, and how these multi-product firms respond to different economic conditions across export markets by varying the number of products they export.[1] In this paper, we further analyze the effects of those export market conditions on the relative export sales of those goods: we refer to this as the firm's product mix choice. We build a theoretical model of multi-product firms that highlights how market size and geography (the market sizes of and bilateral economic distances to trading partners) affects both a firm's exported product range and its exported product mix across market destinations. We show how tougher competition in an export market induces a firm to skew its export sales towards its best performing products (due to a downward shift in the distribution of markups across products). We find very strong confirmation of this competitive effect for French exporters across export market destinations. We also highlight how bilateral trade barriers/enhancers additionally skew a firm's export product mix, after controlling for export market conditions. Our theoretical model shows how this effect of trade barriers and export market competition on a firm's product mix then translates into differences in measured firm productivity. Thus, a firm operating a given technology will produce relatively more output per worker when it exports to markets with tougher competition, or when trade barriers fall. This productivity gain is also compounded by concurrent changes in the mix of exported products in response to those changes in its trading environment.[2]

Feenstra and Ma (2008) and Eckel and Neary (2009) also build theoretical models of multi-product firms that highlight the effect of competition on the distribution of firm product sales. Eckel and Neary (2009) also emphasize the ensuing link between competition and firm productivity. Both models incorporate the cannibalization effect that occurs as large firms expand their product range. In our model, we rely on the competition effects from the demand side, which are driven by variations in the number of sellers and their average prices across export markets. The cannibalization effect does not occur as firms produce a discrete number of products and thus never attain finite mass. The benefits of this simplification is that we can consider an open economy equilibrium with multiple asymmetric countries and asymmetric trade barriers whereas Feenstra and Ma (2008) and Eckel and Neary (2009) restrict their analysis to a single globalized world with no

[1] See Mayer and Ottaviano (2007) for Europe, Bernard et al (2007) for the U.S., and Arkolakis and Muendler (2008) for Latin America.

[2] Bernard et al (2006) and Eckel and Neary (2008) also emphasize this channel between globalization and within-firm productivity changes in a world with symmetric countries. We discuss those papers in further detail below.

trade barriers. Thus, our model is able to capture the key role of geography in shaping differences in competition across export market destinations.[3]

Another approach to the modeling of multi-product firms relies on a nested C.E.S. structure for preferences, where a continuum of firms produce a continuum of products. The cannibalization effect is ruled out by restricting the nests in which firms can introduce new products. Allanson and Montagna (2005) consider such a model in a closed economy, while Arkolakis and Muendler (2008) and Bernard et al (2006) develop extensions to open economies. Given the C.E.S. structure of preferences and the continuum assumptions, markups across all firms and products are exogenously fixed. Thus, differences in market conditions or proportional reductions in trade costs have no effect on a firm's product mix choice (the relative distribution of export sales across products). The latter can only be affected by variations in the delivered costs of the goods (differences in production costs and non-porportional delivery costs). Arkolakis and Muendler (2008) and Bernard et al (2006) document that those cost differences are substantial and that a large proportion of those differences can be attributed to production costs that do not vary across destinations: the distribution of within-firm product export sales is highly skewed, and the ranking of those export sales is highly correlated across export market destinations.[4] We find that the same patterns hold for French exporters. This motivates the concept of a firm's product ladder, starting with its core competency (its best selling product) followed by decreasing productivity/quality ladder for the ensuing products.[5] We also adopt this concept of a core competency and productivity/quality ladder; in our model with endogenous markups, the distribution of exported product sales will vary with market conditions – even after controlling for those cost differences.

Bernard et al (2006) and Baldwin and Gu (2009) also theoretically analyze the effects of a symmetric trade liberalization between symmetric countries. They find that such a liberalization will induce firms to reduce the number/mass of products they produce. Given the productivity differences along the product ladder, Bernard et al (2006) show that this reduction in product scope towards a firm's core competency also leads to within-firm productivity gains for non-exporters (including those firms that are induced to export for the first time).[6] When we restrict our model

[3] Nocke and Yeaple (2008) and Baldwin and Gu (2009) also develop models with multi-product firms and a pro-competitive effect coming from the demand side. These models investigate the effects of globalization on a firm's product scope and average production levels per product. However, those models consider the case of firms producing symmetric products whereas we focus on the effects of competition on the within-firm distribution of product sales.

[4] Arkolakis and Muendler (2008) examine the distribution of product export sales for Brazilian and Chilean firms, while Bernard et al (2006) report those patterns for U.S. firms.

[5] Eckel and Neary (2009) also adopt this modeling concept. Arkolakis and Muendler (2008) and Bernard et al (2006) additionally introduce a stochastic element of the productivity/quality ladder that is market specific.

[6] Eckel and Neary (2009) also find similar effects for an increase in the world market size, absent any trade costs.

to symmetric countries, we also obtain a similar prediction for the effects of trade liberalization. However, our model predicts that trade liberalization will additionally lead firms to skew both domestic and export sales towards their core products (for a given range of products in either market). This opens another channel for within-firm productivity gains from trade liberalization. Empirically, both the effects on product scope and the skewness of the product mix have been documented for the case of trade liberalization in North America. Baldwin and Gu (2009), Bernard et al (2006), and Iacovone and Javorcik (2008) all show how this trade liberalization has induced (respectively) Canadian, U.S., and Mexican firms to reduce the number of products they produce. Baldwin and Gu (2009) and Bernard et al (2006) further report that CUSFTA has induced a significant increase in the skewness of production across products (an increase in entropy). This could be due to an increase in export sales for the 'better' products relative to the marginal products only sold in the domestic economy – absent any changes in the competitive environment; but it could also be due to an increase in the skewness of both export and domestic sales towards the best performing products – which would be explained by an increase in competition due to trade liberalization. Iacovone and Javorcik (2008) show that this is indeed the case for Mexican firms: they report that the exports of a firm's 'better' products (higher export sales) expanded significantly more than those for worse performing products during the period of trade expansion from 1994-2003. Iacovone and Javorcik (2008) also compare the relative contributions of exported product scope and the export product mix (changes in exports of previously exported products) for Mexican exports to the U.S. following NAFTA. They find that changes in the product mix explain the preponderance of the changes in export patterns of Mexican firms. Importantly for the predictions of our model, they find that both expansions as well as contractions in exported product sales (for some firms/products) played an important role. Our theoretical model explains how a symmetric reduction in proportional trade costs induces firms to increase export sales for their best products while simultaneously reducing export sales of other products further down the ladder. The increase in the skewness of both export and domestic sales is driven by the effects of trade liberalization on the toughness of competition across markets.

Our paper proceeds as follows. We first develop a closed economy version of our model in order to focus on the endogenous responses of a firm's product scope and product mix to market conditions. We also show how those choices translate into differences in observable firm performance measures. Even in a closed economy, increases in market size lead to increases in within-firm productivity as well as aggregate productivity gains via reallocations across firms. We then extend our model to an open economy. To fix intuition, we initially abstract from third country effects via geography and develop a 2-country model. We introduce both proportional and non-proportional trade costs across the product ladder – but then show how the consequences of both types of costs can be subsumed within a single trade cost index.[7] We then analyze the effects of multilateral trade liberalization when the trade costs are assumed to be symmetric. We then turn to the multi-country case with an arbitrary matrix of bilateral trade costs. The equilibrium connects differences in market size and geography to the toughness of competition in every market, and how the latter shapes the within-firm distribution of product export sales. Lastly, we empirically test those predictions, examining how market size, geography and trade barriers/enhancers affect that within-firm distribution of product export sales.

2 Closed Economy

We introduce multi-product firms in the model of Melitz and Ottaviano (2008). We start with a closed economy where L consumers each supply one unit of labor.

2.1 Preferences and Demand

Preferences are defined over a continuum of differentiated varieties indexed by $i \in \Omega$, and a homogenous good chosen as numeraire. All consumers share the same utility function given by

$$U = q_0^c + \alpha \int_{i\in\Omega} q_i^c di - \frac{1}{2}\gamma \int_{i\in\Omega} \left(q_i^c\right)^2 di - \frac{1}{2}\eta \left(\int_{i\in\Omega} q_i^c di\right)^2, \tag{1}$$

where q_0^c and q_i^c represent the individual consumption levels of the numeraire good and each variety i. The demand parameters α, η, and γ are all positive. The parameters α and η index the substitution pattern between the differentiated varieties and the numeraire: increases in α and decreases in η both shift out the demand for the differentiated varieties relative to the numeraire. The parameter γ indexes the degree of product differentiation between the varieties. In the limit when $\gamma = 0$, consumers only care about their consumption level over all varieties, $Q^c = \int_{i\in\Omega} q_i^c di$. The varieties are then perfect substitutes. The degree of product differentiation increases with γ as consumers give increasing weight to the distribution of consumption levels across varieties.

The marginal utilities for all goods are bounded, and a consumer may thus not have positive demand for any particular good. We assume that consumers have positive demands for the numeraire

[7] Our empirical results strongly confirm the presence of non-proportional trade costs across the product ladder.

good ($q_0^c > 0$). The inverse demand for each variety i is then given by

$$p_i = \alpha - \gamma q_i^c - \eta Q^c, \tag{2}$$

whenever $q_i^c > 0$. Let $\Omega^* \subset \Omega$ be the subset of varieties that are consumed ($q_i^c > 0$). (2) can then be inverted to yield the linear market demand system for these varieties:

$$q_i \equiv L q_i^c = \frac{\alpha L}{\eta M + \gamma} - \frac{L}{\gamma} p_i + \frac{\eta M}{\eta M + \gamma} \frac{L}{\gamma} \bar{p}, \ \forall i \in \Omega^*, \tag{3}$$

where M is the measure of consumed varieties in Ω^* and $\bar{p} = (1/M) \int_{i \in \Omega^*} p_i di$ is their average price. The set Ω^* is the largest subset of Ω that satisfies

$$p_i \leq \frac{1}{\eta M + \gamma} (\gamma \alpha + \eta M \bar{p}) \equiv p_{\max}, \tag{4}$$

where the right hand side price bound $p_{\max}$ represents the price at which demand for a variety is driven to zero. Note that (2) implies $p_{\max} \leq \alpha$. In contrast to the case of C.E.S. demand, the price elasticity of demand, $\varepsilon_i \equiv |(\partial q_i / \partial p_i)(p_i / q_i)| = [(p_{\max}/p_i) - 1]^{-1}$, is not uniquely determined by the level of product differentiation γ. Given the latter, lower average prices $\bar{p}$ or a larger number of competing varieties M induce a decrease in the price bound $p_{\max}$ and an increase in the price elasticity of demand ε_i at any given p_i. We characterize this as a 'tougher' competitive environment.[8]

Welfare can be evaluated using the indirect utility function associated with (1):

$$U = I^c + \frac{1}{2} \left(\eta + \frac{\gamma}{M} \right)^{-1} (\alpha - \bar{p})^2 + \frac{1}{2} \frac{M}{\gamma} \sigma_p^2, \tag{5}$$

where I^c is the consumer's income and $\sigma_p^2 = (1/M) \int_{i \in \Omega^*} (p_i - \bar{p})^2 di$ represents the variance of prices. To ensure positive demand levels for the numeraire, we assume that $I^c > \int_{i \in \Omega^*} p_i q_i^c di = \bar{p} Q^c - M \sigma_p^2 / \gamma$. Welfare naturally rises with decreases in average prices $\bar{p}$. It also rises with increases in the variance of prices σ_p^2 (holding the mean price $\bar{p}$ constant), as consumers then re-optimize their purchases by shifting expenditures towards lower priced varieties as well as the numeraire good. Finally, the demand system exhibits 'love of variety': holding the distribution of prices constant (namely holding the mean $\bar{p}$ and variance σ_p^2 of prices constant), welfare rises with increases in

[8] We also note that, given this competitive environment (given N and $\bar{p}$), the price elasticity ε_i monotonically increases with the price p_i along the demand curve.

product variety M.

2.2 Production and Firm Behavior

Labor is the only factor of production and is inelastically supplied in a competitive market. The numeraire good is produced under constant returns to scale at unit cost; its market is also competitive. These assumptions imply a unit wage. Entry in the differentiated product sector is costly as each firm incurs product development and production startup costs. Subsequent production of each variety exhibits constant returns to scale. While it may decide to produce more than one variety, each firm has one key variety corresponding to its 'core competency'. This is associated with a core marginal cost c (equal to unit labor requirement).[9] Research and development yield uncertain outcomes for c, and firms learn about this cost level only after making the irreversible investment f_E required for entry. We model this as a draw from a common (and known) distribution $G(c)$ with support on $[0, c_M]$.

The introduction of an additional variety pulls a firm away from its core competency, which we model as higher marginal costs of production for those varieties. We think of these costs increases as also reflecting decreases in product quality/appeal as firms move away from their core competency. For simplicity, we maintain product symmetry on the demand side and capture any decrease in product appeal as an increased production cost. We label the additional production cost for a new variety a customization cost. A firm can introduce any number of new varieties, but each additional variety entails an additional customization cost (as firms move further away from their core competency). We index by m the varieties produced by the same firm in increasing order of distance from their core competency with $m = 0$ referring to the core variety. We then call $v(m, c)$ the marginal cost for variety m produced by a firm with core marginal cost c and assume $v(m, c) = \omega^{-m}c$ with $\omega \in (0, 1)$. This defines a firm-level 'competence ladder'. In the limit, as ω goes to zero, any firm will only produce at most its core variety and we are back to single product firms as in Melitz and Ottaviano (2008).

Since the entry cost is sunk, firms that can cover at least the marginal cost of their core variety survive and produce. All other firms exit the industry. Surviving firms maximize their profits using the residual demand function (3). In so doing, those firms take the average price level $\bar{p}$ and total number of varieties M as given. This monopolistic competition outcome is maintained with

[9] For simplicity, we do not model any overhead production costs. This would significantly increase the complexity of our model without yielding much new insight.

multi-product firms as any firm can only produce a countable number of products, which is a subset of measure zero of the total mass of varieties M.

The profit maximizing price $p(v)$ and output level $q(v)$ of a variety with cost v must then satisfy

$$q(v) = \frac{L}{\gamma}\left[p(v) - v\right]. \tag{6}$$

The profit maximizing price $p(v)$ may be above the price bound $p_{\max}$ from (4), in which case the variety is not supplied. Let v_D reference the cutoff cost for a variety to be profitably produced. This variety earns zero profit as its price is driven down to its marginal cost, $p(v_D) = v_D = p_{\max}$, and its demand level $q(v_D)$ is driven to zero. Firms with core competency $v > v_D$ cannot profitably produce their core variety and exit. $c_D = v_D$ is thus also the cutoff for firm survival. We assume that c_M is high enough that it is always above c_D, so exit rates are always positive. All firms with core cost $c < c_D$ earn positive profits (gross of the entry cost) on their core varieties and remain in the industry. Some firms will also earn positive profits from the introduction of additional varieties. In particular, firms with cost c such that $v(m,c) \le v_D \iff c \le \omega^m c_D$ earn positive profits on their m-th *additional* variety and thus produce at least $m+1$ varieties. The total number of varieties produced by a firm with cost c is[10]

$$M(c) = \begin{cases} 0 & \text{if } c > c_D, \\ \max\{m \mid c \le \omega^m c_D\} + 1 & \text{if } c \le c_D. \end{cases} \tag{7}$$

The number of varieties produced is thus a step function of the firm's productivity $1/c$, as depicted in figure 1 below.

The threshold cost v_D summarizes the competitive environment across all varieties produced by surviving firms. Let $r(v) = p(v)q(v)$, $\pi(v) = r(v) - q(v)v$, $\lambda(v) = p(v) - v$ denote the revenue, profit, and (absolute) markup of a variety with cost v. All these performance measures can then

[10] Note that this is an integer number, and not a mass with positive measure.

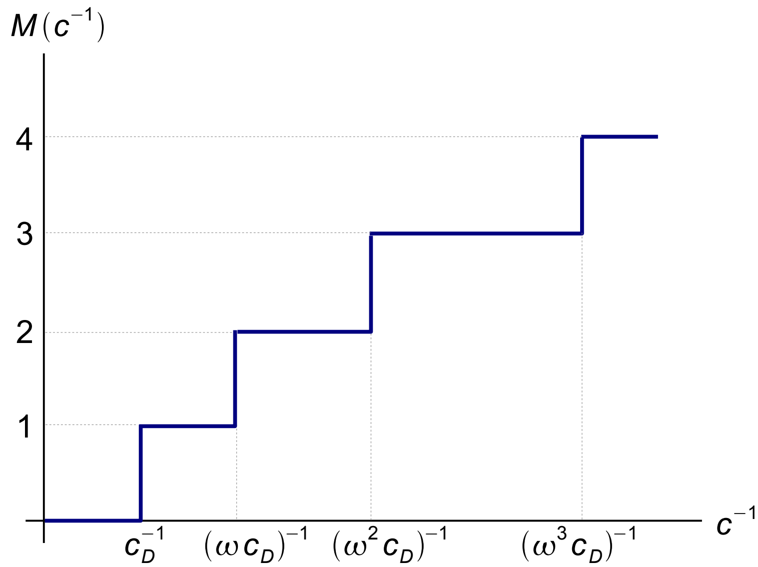

Figure 1: Number of Varieties Produced as a Function of Firm Productivity

be written as functions of v and v_D only:

$$p(v) = \frac{1}{2}(v_D + v), \tag{8}$$

$$\lambda(v) = \frac{1}{2}(v_D - v), \tag{9}$$

$$q(v) = \frac{L}{2\gamma}(v_D - v), \tag{10}$$

$$r(v) = \frac{L}{4\gamma}\left[(v_D)^2 - v^2\right], \tag{11}$$

$$\pi(v) = \frac{L}{4\gamma}(v_D - v)^2. \tag{12}$$

As expected, lower cost varieties have lower prices and earn higher revenues and profits than varieties with higher costs. However, lower cost varieties do not pass on all of the cost differential to consumers in the form of lower prices: they also have higher markups (in both absolute and relative terms) than varieties with higher costs.

All these performance measures can be aggregated to the firm level:

$$Q(c) \equiv \sum_{m=0}^{M(c)-1} q\left(v\left(m,c\right)\right),$$
$$R(c) \equiv \sum_{m=0}^{M(c)-1} r\left(v\left(m,c\right)\right),$$
$$\Pi(c) \equiv \sum_{m=0}^{M(c)-1} \pi\left(v\left(m,c\right)\right), \tag{13}$$

where $Q(c)$, $R(c)$, $\Pi(c)$ denote total firm output, revenue, and profit. Firm-level measures for prices and markups are now best expressed as averages (weighted by relative output across varieties):

$$\bar{P}(c) \equiv \frac{R(c)}{Q(c)} \qquad \text{and} \qquad \bar{\Lambda}(c) \equiv \frac{\Pi(c)}{Q(c)}.$$

We also define an average cost measure at the firm-level in a similar way (average cost per unit produced):

$$\bar{C}(c) \equiv \frac{C(c)}{Q(c)},$$

where $C(c) = R(c) - \Pi(c)$ is the firm's total production cost across all varieties. $\bar{C}(c)$ is an inverse measure of a firm's overall productivity measured as physical output units per unit input (labor). Empirically, physical units of output are often not accurately recorded (especially for multi-product firms) and productivity is then measured as value-added per worker. This productivity measure corresponds to $\bar{\Phi}(c) \equiv R(c)/C(c) = \left[\bar{\Lambda}(c)/\bar{C}(c)\right] + 1$ in our model. The last derivation makes clear how the measured productivity $\bar{\Phi}(c)$ combines the effects of both better physical productivity $1/\bar{C}(c)$ as well as higher average markups $\bar{\Lambda}(c)$. Given a competitive environment summarized by $v_D = c_D$, we show in the appendix that all of these average firm performance measures, $\bar{C}(c), \bar{\Phi}(c), \bar{P}(c), \bar{\Lambda}(c)$ are monotonic functions of the firm's core competency c. A firm with a better core competency (lower c) will be more productive (lower $\bar{C}(c)$ and higher $\bar{\Phi}(c)$), and set lower average prices $\bar{P}(c)$ though higher average markups $\bar{\Lambda}(c)$. However, a key feature of our model with multi-product firms will be that all of these firm performance measures will respond to changes in the competitive environment (summarized by $v_D = c_D$) – unlike the core competency measure c.

Given a mass of entrants N_E, the distribution of costs across all varieties is determined by the distribution of core competencies $G(c)$ as well as the optimal firm product range choice $M(c)$. Let $M_v(v)$ denote the measure function for varieties (the measure of varieties produced at cost v or lower, given N_E entrants). Further define $H(v) \equiv M_v(v)/N_E$ as the normalized measure of varieties per unit mass of entrants. Then $H(v) = \sum_{m=0}^{\infty} G(\omega^m v)$ and is exogenously determined from $G(.)$ and ω. Given a unit mass of entrants, there will be a mass $G(v)$ of varieties with cost v or less; a mass $G(\omega v)$ of first additional varieties (with cost v or less); a mass $G(\omega^2 v)$ of second additional varieties; and so and so forth. The measure $H(v)$ sums over all these varieties.

2.3 Free Entry and Flexible Product Mix

Prior to entry, the expected firm profit is $\int_0^{c_D} \Pi(c)dG(c) - f_E$. If this profit were negative, no firms would enter the industry. As long as some firms produce, the expected profit is driven to zero by the unrestricted entry of new firms. This yields the equilibrium free entry condition:

$$\begin{aligned}\int_0^{c_D} \Pi(c)dG(c) &= \int_0^{c_D} \left[\sum_{\{m|\omega^{-m}c \leq c_D\}} \pi\left(\omega^{-m}c\right) \right] dG(c) \\ &= \sum_{m=0}^{\infty} \left[\int_0^{\omega^m c_D} \pi\left(\omega^{-m}c\right) dG(c) \right] = f_E, \end{aligned} \tag{14}$$

which determines the cost cutoff $c_D = v_D$. This cutoff, in turn, determines the aggregate mass of varieties, since $v_D = p(v_D)$ must also be equal to the zero demand price threshold in (4):

$$v_D = \frac{1}{\eta M + \gamma}\left(\gamma\alpha + \eta M\bar{p}\right).$$

The aggregate mass of varieties is then

$$M = \frac{2\gamma}{\eta}\frac{\alpha - v_D}{v_D - \overline{v}}, \tag{15}$$

where the average cost of all varieties

$$\overline{v} = \frac{1}{M}\int_0^{v_D} v dM_v(v) = \frac{1}{N_E H(v_D)}\int_0^{v_D} v N_E dH(v) = \frac{1}{H(v_D)}\int_0^{v_D} v dH(v)$$

depends only on v_D.[11] Finally, the mass of entrants is given by $N_E = M/H(v_D)$, which can in turn be used to obtain the mass of producing firms $N = N_E G(c_D)$.

[11] We also use the relationship between average cost and price $\bar{v} = 2\bar{p} - v_D$, which is obtained from (8).

2.4 Parametrization of Technology

All the results derived so far hold for any distribution of core cost draws $G(c)$. However, in order to simplify some of the ensuing analysis, we use a specific parametrization for this distribution. In particular, we assume that core productivity draws $1/c$ follow a Pareto distribution with lower productivity bound $1/c_M$ and shape parameter $k \geq 1$. This implies a distribution of cost draws c given by

$$G(c) = \left(\frac{c}{c_M}\right)^k, \ c \in [0, c_M]. \tag{16}$$

The shape parameter k indexes the dispersion of cost draws. When $k = 1$, the cost distribution is uniform on $[0, c_M]$. As k increases, the relative number of high cost firms increases, and the cost distribution is more concentrated at these higher cost levels. As k goes to infinity, the distribution becomes degenerate at c_M. Any truncation of the cost distribution from above will retain the same distribution function and shape parameter k. The productivity distribution of surviving firms will therefore also be Pareto with shape k, and the truncated cost distribution will be given by $G_D(c) = (c/c_D)^k, \ c \in [0, c_D]$.

When core competencies are distributed Pareto, then all produced varieties will share the same Pareto distribution:

$$H(c) = \sum_{m=0}^{\infty} G(\omega^m c) = \Omega G(c),$$

where $\Omega = \left(1 - \omega^k\right)^{-1} > 1$ is an index of multi-product flexibility (which varies monotonically with ω). In equilibrium, this index will also be equal to the average number of products produced across all surviving firms:

$$\frac{M}{N} = \frac{H(v_D)}{G(c_D)} = \Omega.$$

The Pareto parametrization also yields a simple solution for the cost cutoff c_D from the free entry condition (14):

$$c_D = \left[\frac{\gamma\phi}{L\Omega}\right]^{\frac{1}{k+2}}, \tag{17}$$

where $\phi \equiv 2(k+1)(k+2)\left(c_M\right)^k f_E$ is a technology index that combines the effects of better distribution of cost draws (lower c_M) and lower entry costs f_E. We assume that $c_M > \sqrt{\left[2(k+1)(k+2)\gamma f_E\right] / \left(L\Omega\right)}$ in order to ensure that $c_D < c_M$ as was previously anticipated. Note that, in the limit, when the marginal costs of non-core varieties becomes infinitely large ($\omega \to 0$), multi-product flexibility Ω goes to one (no multi product firms) and (17) boils down to the single-product case studied by Melitz and Ottaviano (2008). The average marginal cost across varieties is then

$$\overline{v} = \frac{k}{k+1} v_D$$

and the mass of available varieties (see (15) is

$$M = \frac{2(k+1)\gamma}{\eta} \frac{\alpha - c_D}{c_D}. \tag{18}$$

Since the cutoff level completely summarizes the distribution of prices as well as all the other performance measures, it also uniquely determines welfare from (5):

$$U = 1 + \frac{1}{2\eta} (\alpha - c_D) \left(\alpha - \frac{k+1}{k+2} c_D \right). \tag{19}$$

Welfare increases with decreases in the cutoff c_D, as the latter induces increases in product variety M as well as decreases in the average price $\bar{p}$ (these effects dominate the negative impact of the lower price variance).[12]

Increases in market size, technology improvements (a fall in c_M or f_E), or increases in product substitutability lead to decreases in the cutoff c_D and increases in both the mass of varieties produced, and the mass of surviving firms. Although the average number of varieties produced per firm remains constant at Ω, all firms respond to this tougher competition by decreasing the number of products produced: $M(c)$ is (weakly) decreasing for all $c \in [0, c_M]$. The average $M(c)$ remains constant due to the effects of selection (higher cost firms producing the fewest number of products exit). Thus, tougher competition induces firms to focus on the production of varieties that are closer to its core competency. In addition, this tougher competitive environment induces firms to reallocate labor resources among the remaining products produced towards the production of the core varieties (lower m).[13] Within-firm productivity $1/\bar{C}(c)$ thus increases due to the compounding effects of this reallocation and the product selection effect. Aggregate productivity (the inverse of the economy wide average cost of production) thus increases due to both a within-firm and across-firm selection effect. Output and sales per variety increases for all surviving products, and the distribution of markups across these products shifts down. Welfare increases due to higher

[12] This welfare measure reflects the reduced consumption of the numeraire to account for the labor resources used to cover the entry costs.

[13] In other words, tougher competition induces an increase in a firm's relative production levels of varieties with lower m (closer to the core). More precisely, $q\left(v\left(m_1, c\right)\right)/q\left(v\left(m_2, c\right)\right)$ increases whenever $m_1 < m_2$.

productivity and product variety, and lower markups.

3 Open Economy

For expositional purposes, we initially develop a two country version of this model before turning to the multi-country case. We thus consider a two economy world, H and F, with L^H and L^F consumers in each country. The markets are segmented, although any produced variety can be exported. This entails an additional customization cost (over and above the customization for the domestic market) with 'step cost' ladder $1/\theta^l$, $\theta^l \in (0,1]$, for exports to country $l = \{H, F\}$. There is also an iceberg trade cost $\tau^l > 1$ that is incurred once for each variety that is exported to l. For notational convenience, we subsume the first customization cost $1/\theta^l$ into this iceberg trade cost so that we can write the marginal cost of an exported variety from country $h = \{H, F\} \neq l$ to country l as $v_X^h(m,c) = \left(\theta^l \omega\right)^{-m} c$, with delivered cost $\tau^l v_X^h(m,c)$. ω^{-1} remains the step cost for varieties produced on each domestic market, leading to the same marginal cost function for variety m, $v_D(m,c) = \omega^{-m} c$.[14] Let $\omega^l \equiv \theta^l \omega \leq \omega$ denote the combined (inverse) step cost for exported varieties to country l. Throughout our analysis, we allow for the possibility of $\theta^l = 1$ $\left(\omega^l = \omega\right)$, which is a natural benchmark of no step-differences between exported and domestic varieties. In that case, τ^l is the only trade cost and there are no variations across destinations in relative delivered costs $\left[\tau^l v_X^h(m,c)\right] / \left[\tau^l v_X^h(m',c)\right] = \omega^{m'-m}$ for any two exported varieties m, m' by a given firm. Variations in θ^l allow us to consider cases where that relative delivered cost will vary across destinations for a firm. We find strong confirmation of this effect in our empirical results.

Let $p_{\max}^l$ denote the price threshold for positive demand in market l. Then (4) implies

$$p_{\max}^l = \frac{1}{\eta M^l + \gamma}\left(\gamma\alpha + \eta M^l \bar{p}^l\right), \tag{20}$$

where M^l is the total number of products selling in country l (the total number of domestic and exported varieties) and $\bar{p}^l$ is their average price. Let $\pi_D^l(v)$ and $\pi_X^l(v)$ represent the maximized value of profits from domestic and export sales for a variety with cost v produced in country l.[15]

[14] Our model can easily accommodate differences in the step cost ω across countries. In this paper, we do not focus on those cross-country differences and assume the same ω for notational convenience.

[15] Recall that $v_X^h(m,c) \geq v_D(m,c)$ with a strict inequality whenever $\theta^l < 1$ and $m > 0$. In those cases, a firm that produces variety m at cost v for the domestic market cannot produce that same variety at cost v for the export market. Thus, in general, $\pi_D^l(v)$ and $\pi_X^l(v)$ do not refer to domestic and export profits for the *same* variety m.

The cost cutoffs for profitable domestic production and for profitable exports must satisfy:

$$\begin{aligned} v_D^l &= \sup\left\{c : \pi_D^l(v) > 0\right\} = p_{\max}^l, \\ v_X^l &= \sup\left\{c : \pi_X^l(v) > 0\right\} = \frac{p_{\max}^h}{\tau^h}, \end{aligned} \tag{21}$$

and thus $v_X^l = v_D^h/\tau^h$. As was the case in the closed economy, the cutoff v_D^l, $l = \{H, F\}$, summarizes all the effects of market conditions in country l relevant for all firm performance measures. The profit functions can then be written as a function of these cutoffs:

$$\begin{aligned} \pi_D^l(v) &= \frac{L^l}{4\gamma}\left(v_D^l - v\right)^2, \\ \pi_X^l(v) &= \frac{L^h}{4\gamma}\left(\tau^h\right)^2\left(v_X^l - v\right)^2 = \frac{L^h}{4\gamma}\left(v_D^h - \tau^h v\right)^2. \end{aligned} \tag{22}$$

As in the closed economy, $c_D^l = v_D^l$ will be the cutoff for firm survival in country l. Similarly, $c_X^l = v_X^l$ will be the firm export cutoff (no firm with $c > c_X^l$ can profitably export any varieties). A firm with core competency c will produce all varieties m such that $\pi_D^l\left[v_D(m,c)\right] = \pi_D^l\left(\omega^{-m}c\right) \geq 0$, and will export the subset of varieties m such that $\pi_X^l\left[v_X(m,c)\right] = \pi_X^l\left[\left(\omega^l\right)^{-m} c\right] \geq 0$. The total number of varieties produced and exported by a firm with cost c in country l are thus

$$M_D^l(c) = \begin{cases} 0 & \text{if } c > c_D^l, \\ \max\left\{m \mid c \leq \omega^m c_D^l\right\} + 1 & \text{if } c \leq c_D^l, \end{cases}$$

$$M_X^l(c) = \begin{cases} 0 & \text{if } c > c_X^l, \\ \max\left\{m \mid c \leq \left(\omega^l\right)^m c_X^l\right\} + 1 & \text{if } c \leq c_X^l. \end{cases}$$

We can then define a firm's total domestic and export profits by aggregating over these varieties:

$$\Pi_D^l(c) = \sum_{m=0}^{M_D^l(c)-1} \pi_D^l\left[v\left(m,c\right)\right], \qquad \Pi_X^l(c) = \sum_{m=0}^{M_X^l(c)-1} \pi_X^l\left[v_X^l\left(m,c\right)\right].$$

Entry is unrestricted in both countries. Firms choose a production location prior to entry and paying the sunk entry cost. We assume that the entry cost f_E and cost distribution $G(c)$ are identical in both countries (although this can be relaxed). We also assume the same Pareto parametrization (16) for core competencies in both countries. A prospective entrant's expected profits will then be given by

$$
\begin{aligned}
&\int_0^{c_D^l} \Pi_D^l(c)dG(c) + \int_0^{c_X^l} \Pi_X^l(c)dG(c) \\
&= \sum_{m=0}^{\infty} \left[\int_0^{\omega^m c_D^l} \pi_D^l \left(\omega^{-m} c\right) dG(c) \right] + \sum_{m=0}^{\infty} \left[\int_0^{\left(\omega^l\right)^m c_X^l} \pi_X^l \left[\left(\omega^l\right)^{-m} c \right] dG(c) \right] \\
&= \frac{1}{2\gamma(k+1)(k+2)\left(c_M\right)^k} \left[L^l \Omega \left(c_D^l\right)^{k+2} + L^h \Omega^h \left(\tau^h\right)^2 \left(c_X^l\right)^{k+2} \right] \\
&= \frac{\Omega}{2\gamma(k+1)(k+2)\left(c_M\right)^k} \left[L^l \left(c_D^l\right)^{k+2} + L^h \frac{\Omega^h}{\Omega} \left(\tau^h\right)^{-k} \left(c_D^h\right)^{k+2} \right],
\end{aligned}
$$

where we define $\Omega^h \equiv \left[1 - \left(\omega^h\right)^k\right]^{-1}$ in an analogous way to Ω and use the relationship $c_D^h = \tau^h c_X^l$. Setting the expected profit equal to the entry cost yields the free entry condition

$$
L^l \left(c_D^l\right)^{k+2} + L^h \rho^h \left(c_D^h\right)^{k+2} = \frac{\gamma\phi}{\Omega}, \tag{23}
$$

where $\rho^h \equiv \left(\Omega^h/\Omega\right)\left(\tau^h\right)^{-k} < 1$ is a measure of 'freeness' of trade to country h that incorporates both the 'physical' trade cost τ^h as well as the step differences between domestic and export market customization. The technology index ϕ is the same as in the closed economy case. The two free entry conditions for $l = H, F$ can be solved to yield the cutoffs in both countries

$$
c_D^l = \left[\frac{\gamma\phi}{\Omega L^l} \frac{1-\rho^h}{1-\rho^l \rho^h} \right]^{\frac{1}{k+2}}.
$$

As in the closed economy, the threshold price condition in country l (20), along with the resulting Pareto distribution of all prices for varieties sold in l (domestic prices and export prices have an identical distribution in country l) yield a zero-cutoff profit condition linking the variety cutoff $v_D^l = c_D^l$ to the mass of varieties sold in country l :

$$
M^l = \frac{2(k+1)\gamma}{\eta} \frac{\alpha - c_D^l}{c_D^l}. \tag{24}
$$

Given a positive mass of entrants N_E^l in both countries, the total mass of varieties sold in country l will also be given by $M^l = \Omega G(c_D^l) N_E^l + \Omega^l G(c_X^h) N_E^h$. The first term represents the number of varieties produced for the domestic market by the N_E^l entrants in l; and the second term represents the number of exported varieties by the N_E^h entrants in country h. This condition (holding for each country) can be solved for the number of entrants in each country:

$$
\begin{aligned}
N_E^l &= \frac{(c_M)^k}{\Omega\left(1-\rho^l\rho^h\right)}\left[\frac{M^l}{\left(c_D^l\right)^k} - \rho^l \frac{M^h}{\left(c_D^h\right)^k}\right] \\
&= \frac{2\,(c_M)^k\,(k+1)\,\gamma}{\Omega\eta\left(1-\rho^l\rho^h\right)}\left[\frac{\alpha - c_D^l}{\left(c_D^l\right)^{k+1}} - \rho^l \frac{\alpha - c_D^h}{\left(c_D^h\right)^{k+1}}\right].
\end{aligned} \tag{25}
$$

3.1 Trade Liberalization

When trade costs are symmetric ($\rho^l = \rho^h = \rho$), then the cost cutoffs in both countries decrease monotonically as trade costs are reduced (ρ increases) – including the transition from autarky ($\rho = 0$). This increase in the toughness of competition induces the same firm and product reallocations that were previously described for the closed economy: firms drop their marginal products and focus on products closer to their core competency; they also re-allocate their labor resources towards the production of those 'core' varieties (lower m). Thus, firm productivity increases due to these compounding effects. The inter-firm reallocations (the lowest productivity firms exit) generate an additional aggregate productivity increase.

4 Exporter Product Scope and Product Mix

We now examine how market size and geography determine differences in the toughness of competition across markets – and how the latter translates into differences in the exporters' product mix. We allow for an arbitrary number of countries and asymmetric trade costs. Let J denote the number of countries, indexed by $l = 1, ..., J$. We assume that firms everywhere face the same step cost ω^{-1} for varieties produced for their domestic market, but now allow the additional customization cost for exports from l to h, $\left(\theta^{lh}\right)^{-1} \geq 1$, to vary across country-pairs. This leads to differences in the combined (inverse) step-cost $\left(\omega^{lh}\right)^{-1} \equiv \left(\theta^{lh}\omega\right)^{-1} \geq 1$ across country-pairs. We also allow the iceberg trade cost $\tau^{lh} > 1$ to vary across country-pairs. As with our two-country version, we define the overall 'freeness' of trade for exports from country l to h as $\rho^{lh} \equiv \left(\Omega^{lh}/\Omega\right)\left(\tau^{lh}\right)^{-k} < 1$, where $\Omega^{lh} \equiv \left[1 - \left(\omega^{lh}\right)^k\right]^{-1}$. We also allow for the possibility of internal trade cost so that τ^{ll} may also be above 1. If not, then $\rho^{ll} = 1$, since $\Omega^{ll} = \Omega$ by definition. We continue to assume that firm productivity $1/c$ is distributed Pareto with shape k and support $[0, c_M]$ in all countries.[16]

[16] Differences in the support for this distribution could also be introduced as in Melitz and Ottaviano (2008).

In this extended model, the free entry condition (23) in country l becomes:

$$\sum_{h=1}^{J} \rho^{lh} L^h \left(c_D^h\right)^{k+2} = \frac{\gamma\phi}{\Omega} \qquad l = 1, ..., J.$$

This yields a system of J equations that can be solved for the J equilibrium domestic cutoffs using Cramer's rule:

$$c_D^l = \left(\frac{\gamma\phi}{\Omega} \frac{\sum_{h=1}^{J} |C_{hl}|}{|P|} \frac{1}{L^l} \right)^{\frac{1}{k+2}}, \tag{26}$$

where $|P|$ is the determinant of the trade freeness matrix

$$P \equiv \begin{pmatrix} \rho^{11} & \rho^{12} & \cdots & \rho^{1M} \\ \rho^{21} & \rho^{22} & \cdots & \rho^{2M} \\ \vdots & \vdots & \ddots & \vdots \\ \rho^{M1} & \rho^{M2} & \cdots & \rho^{MM} \end{pmatrix},$$

and $|C_{hl}|$ is the cofactor of its ρ^{hl} element. Cross-country differences in cutoffs now arise from two sources: own country size (L^l) and geographical remoteness, captured by $\sum_{h=1}^{J} |C_{hl}| / |P|$ (an inverse measure of market access and supplier potential). Countries benefiting from a larger local market or better market potential have lower cutoffs, and exhibit tougher competition.

The mass of varieties M^l sold in each country l (including domestic producers in l and exporters to l) is still given by (24). Given a positive mass of entrants N_E^h in country h, there will be $G(c_X^{hl})N_E^h$ firms exporting $\Omega^{hl} G(c_X^{hl})N_E^h$ varieties to country l. Summing over all these varieties (including those produced and sold in l) yields[17]

$$\sum_{h=1}^{J} \rho^{hl} N_E^h = \frac{M^l}{\Omega \left(c_D^l\right)^k}.$$

The latter provides a system of J linear equations that can be solved for the number of entrants in the J countries using Cramer's rule:[18]

$$N_E^l = \frac{\phi\gamma}{\Omega\eta (k+2) f_E} \sum_{h=1}^{J} \frac{\left(\alpha - c_D^h\right)}{\left(c_D^h\right)^{k+1}} \frac{|C_{lh}|}{|P|}. \tag{27}$$

[17] Note that $c_D^l = \tau^{hl} c_X^{hl}$.

[18] We use the properties that relate the freeness matrix P and its transpose in terms of determinants and cofactors.

4.1 Bi-Lateral Trade Patterns and the Margins of Export

We now investigate the predictions of this multi-country trade model for the composition of bi-lateral trade flows. A variety produced in country l at cost v for the export market to h generates export sales

$$r_X^{lh}(v) = \frac{L^h}{4\gamma}\left[\left(v_D^h\right)^2 - \left(\tau^{lh}v\right)^2\right]. \tag{28}$$

Then $EXP^{lh} = N_E^l \Omega^{lh} \int_0^{c_X^{lh}} r_X^{lh}(v)dG(v)$ represents the aggregate bi-lateral trade from l to h across the $N_E^l \Omega^{lh} G(c_X^{lh})$ exported varieties. This aggregate trade flow can be decomposed into the product of the number of exporting firms, $N_X^{lh} \equiv N_E^l G(c_X^{lh})$, the average number of exported varieties per firm, Ω^{lh}, and the average export flow per variety, $\bar{r}_X^{lh} \equiv \left[\int_0^{c_X^{lh}} r_X^{lh}(v)dG(v)\right]/G(c_X^{lh})$. This last term, capturing the product-intensive margin of trade only depends on the characteristics of the import market h:

$$\bar{r}_X^{lh} = \frac{L^h}{2\gamma\,(k+2)}\left(c_D^h\right)^2.$$

Lower trade barriers to from l to h will clearly increase the export flow $r_X^{lh}(v)$ for any exported variety. However, the lower trade barriers will also induce new varieties to be exported to h. Since these new exported varieties will have the lowest trade volumes, these two effects will generate opposite forces on the average export flow $\bar{r}_X^{lh}$. Given our parametrization, these opposing forces exactly cancel out. We do not emphasize this exact result, but rather the presence of opposing forces generating the relationship between trade costs and average exports per variety. On the other hand, increases in importer country size generate unambiguous predictions for this intensive margin of trade: Increases in country size toughen the selection effect for exported varieties (skewing the distribution towards varieties with higher trade volumes), and also generates increases in export flows $r_X^{lh}(v)$ for the varieties with the largest trade volumes (lower v).

Trade costs τ^{lh} as well as differences in importer characteristics generate ambiguous effects on the average number of exported varieties per firm: Higher trade costs or tougher competition in h will both reduce the number of exported varieties by any given exporting firm. However, they will also generate a selection effect among firms: lower productivity firms exporting the smallest number of varieties exit the export market. Given our parametrization, these opposing forces cancel out, leaving the average number of exported varieties Ω^{lh} unchanged. Again, we emphasize the presence of competing forces for this margin of trade. However, changes in the additional step cost associated with customization for the export market in h do generate unambiguous predictions for the average number of exported varieties per firm: decreases in this additional cost will increase the average number of exported varieties, as all firms export more varieties.

Lastly, exporter and importer country characteristics, as well as trade barriers will have a predictable effect on the number of exporting firms:

$$N_X^{lh} = N_E^l G(c_D^h) \left(\tau^{lh}\right)^{-k}.$$

There are no countervailing forces at this final extensive margin: anything that makes it harder for firms from country l to break into the export market in h (higher trade barriers or tougher competition in h) will decrease the number of exporting firms. Holding those forces constant, an increase in the number of entrants (into production) in l will proportionally increase in the number of exporting firms to any given destination.

5 French Exporters' Product Mix Across Destinations

We now focus on the predictions of our extended model for the within firm distribution of product sales across export market destinations. A French firm ($l = France$) with core competency c that exports variety m to location h will generate export sales (see (28)):

$$\begin{aligned} r_{XF}^h(m,c) &= r_X^{lh}(\left[\theta^{lh}\omega\right]^{-m} c) \\ &= \frac{L^h}{4\gamma}\left\{\left(v_D^h\right)^2 - \left[\tau^{lh}\left(\theta^{lh}\omega\right)^{-m} c\right]^2\right\}. \end{aligned} \tag{29}$$

For any two exported varieties m and m' to h, the ratio of export sales will depend on the toughness of competition in the destination h (inversely related to v_D^h) and on the bilateral trade costs τ^{lh} and θ^{lh}. Holding the latter fixed, inspection of (29) reveals that an increase in the toughness of competition (captured by a lower v_D^h) will skew export sales towards varieties closer to the core (lower m).[19] More precisely the ratio of export sales $r_{XF}^h(m,c)/r_{XF}^h(m',c)$ for any two varieties m, m' increases with decreases in v_D^h so long as $m < m'$.[20] In the appendix, we show that this key prediction for the effects of tougher competition holds for a wide set of demand parametrization – where tougher competition is interpreted as higher demand price elasticities at any given price.

[19] In equilibrium, a lower v_D^h in a country is associated with a downward shift in the distribution of markups across all products sold in that market (which we characterize as tougher competition).

[20] The elasticity of $r_{XF}^h(m,c)$ with respect to v_D^h is $\left[L^h\left(v_D^h\right)^2/2\gamma\right]\left[r_{XF}^h(m,c)\right]^{-1}$, which increases with m.

The firm responds by lowering markups across all exported products, which increases the relative sales of its better performing products (selling at a lower 'quality adjusted' relative price).

We can also use (29) to generate predictions for the response of that same within-firm ratio of export sales to differences in trade costs. Holding the toughness of competition fixed, an increase in either trade cost (higher τ^{lh} or lower θ^{lh}) will skew export sales towards varieties closer to the core (the ratio of export sales for varieties m and m' increases for $m < m'$). In the case of the proportional trade cost τ^{lh}, this effect is driven by increases in demand price elasticities at higher cost levels since the ratio of delivered cost is unaffected by τ^{lh}. This is a feature of the linear demand system that price elasticity increases as a firm moves up its demand curve (this feature is shared with most other parametrization of demand that do not feature exogenous price elasticities). Thus, the effect of higher proportional trade costs is very similar to tougher competition: the higher delivered cost for some firms makes competition tougher for them at any given cutoff level v_D^h in that market – and they respond by adjusting their markups downward on all exported goods. A higher customization cost increment $1/\theta^{lh}$ also generates a similar effect, inducing lower markups across the exported product line. However, this cost increases disproportionately hits products further away from the core, driving up their delivered costs relative to varieties closer to the core. This directly translates into higher relative export sales for the varieties closer to the core.

We note that our theoretical model does not restrict the pattern of correlation between both types of trade costs. If they are positively correlated, then higher trade costs will affect disproportionately more varieties further away from the core. Higher trade costs then lead to higher relative export sales for the varieties closer to the core. If they are negatively correlated then higher trade costs will affect those varieties proportionately less. In that case, a higher trade cost for the core variety can lead to *lower* relative export sales for the varieties closer to the core. We find empirical support for both of these cases, depending on the nature of the trade barrier.

In summary, we can test for differences in competition across export markets by examining the response of the ratio of exported sales for a given firm and given varieties m and m' – after controlling for the bilateral trade costs. If a bilateral trade barrier exhibits either proportional trade costs (across the product line) or increasing trade costs, then higher levels of that trade barrier will induce higher relative export sales for varieties closer to the core – after controlling for the effects of market competition in that destination (common for exporters from any source country). On the other hand, if a bilateral trade barrier exhibits trade costs that increase less than proportionally along the product ladder, then it is possible for the trade barrier to induce lower relative export sales for varieties closer to the core.

5.1 Data

We test these predictions using comprehensive firm-level data on annual shipments by all French exporters to all countries in the world for a set of more than 10,000 goods. Firm-level exports are collected by French customs and include export sales for each 8-digit (combined nomenclature) product by destination country.[21] A firm located in the French metropolitan territory must report this detailed export information so long as the following criteria are met: For within EU exports, the firm's annual trade value exceeds 250,000 Euros;[22] and for exports outside the EU, the exported value to a destination exceeds 1,000 Euros or a weight of a ton. Despite these limitations, the database is nearly comprehensive. In a given year (on average), 102,300 firms report exports across 225 destination countries (or territories) for 11,578 products. This represents data on over 2 million shipments per year. We restrict our analysis to export data for 2000, and eliminate firms in the service and wholesale/distribution sector to ensure that firms take part in the production of the goods they export. This leaves us with data on over a million shipments by firms in the manufacturing and agriculture sectors.[23]

We use three different measures to capture the skewness of a firm's export sales (within destinations). The first measure is closest to the modelling assumptions and assumes a product ladder that does vary across destinations. We thus rank all the products exported by a firm according to its exports to the world, and use this ranking as an indicator for the product rank m_i. As we briefly mentioned in the introduction, this ranking is highly correlated with a similar ranking of products across destinations based on export sales to that destination. The Spearman rank correlation between these measures is .68. Although high, this correlation still highlights substantial departures from a steady global product ladder. Another alternative is to use the country specific rank as an indicator for the product rank m_i. In this interpretation, the identity of the core (or other rank number) product can change across destinations. Our assumptions on the delivered costs across the product ladder then hold for a specific rank in the product ladder, and not for a particular product. We can thus use either the product global rank, or the within destination product rank to generate export sales ratio $r_X^{lh}(v_X^h(m,c))/r_X^{lh}(v_X^h(m',c))$ for $m < m'$. Since many firms export few

[21] We thank French customs for making this data available to researchers at the CEPII.

[22] If that threshold is not met, firms can choose to report under a simplified scheme without supplying export destinations. However, in practice, many firms under that threshold report the detailed export destination information.

[23] Some large distributors such as Carrefour account for a disproportionate number of annual shipments.

products to many destinations, increasing the higher product rank m' disproportionately reduces the number of available firm/destination observations. For most of our analysis, we pick $m = 0$ (core product) and $m' = 1$, but also report results for $m' = 2$.[24] Thus, we construct the ratio of a firm's export sales to every destination for its best performing product (either globally, or in each destination) relative to its next best performing product (again, either globally, or in each destination). The local ratios can be computed so long as a firm exports at least two products to a destination (or three when $m' = 2$). The global ratios can be computed so long as a firm exports its top (in terms of world exports) two products to a destination. We thus obtain these measures that are firm-destination specific, so long as those criteria are met. We use those ratios in logs, so that they represent percentage differences in export sales. We refer to the ratios as either local or global, based on the ranking method used to compute them.

Our third measure seeks to capture changes in skewness over the entire range of exported products (instead of being confined to the top two or three products). We use a Theil index (a measure of entropy) for the distribution of firm export sales to a destination. This yields a measure of skewness for every firm-destination combination such that the firm exports two or more products to that destination.[25] Our choice of the Theil index is motivated by the fact that it is invariant to truncation when the underlying distribution is Pareto, and that this distribution provides a very good fit for the within-firm distribution of export sales to a destination.[26] As with two ratio measures, a higher Theil index indicates a more skewed distribution of export sales towards the firm's best product.

Our theoretical model predicts that the toughness of competition in a destination is determined by that destination's size, and by its geography (proximity to other big countries). We control for country size using GDP expressed in a common currency at market exchange rates. We now seek a control for the geography of a destination that does not rely on country-level data for that destination. We use the *supply potential* concept introduced by Redding and Venables (2004) as such a control. Intuitively, the supply potential is the aggregate predicted exports to a destination based on a bilateral trade gravity equation (in logs) with both exporter and importer fixed effects and the standard bi-lateral measures of trade barriers/enhancers. We then construct the predicted aggregate

[24] We also obtain very similar results for $m = 1$ and $m' = 2$.

[25] We also experiment by dropping firm-destinations at the extremes of the distribution for the number of products exported to that destination. We will also control directly for the number of exported products to reduce any mechanical impact of that number on the measure of skewness.

[26] The median r-squared for the within firm-destination regression of log rank on log size (for firms exporting more than 10 products) is .90.

exports to each destination without using the importer fixed effects (and thus uncorrelated with the importer fixed effect by construction). We call this measure a destination's *foreign supply potential.* Its construction is closely related to that of a country's market potential (which seeks to capture a measure of predicted import demand for a country).[27] The construction of the supply potential measures is discussed in greater detail in Redding and Venables (2004); we use the foreign supply measure for the year 2000 from Mayer (2008) who extends the analysis to many more countries and more years of data.[28] We also use two independent controls for bilateral trade barriers between France and the destination country: distance and a common-language indicator.

5.2 Results

Before reporting the regression results of the skewness measures on the destination country measures, we first show some scatter plots for the global ratio with both destination country GDP and our measure of foreign supply potential. For each destination, we use the mean global ratio across exporting firms. Since the firm-level measure is very noisy, the precision of the mean increases with the number of available firm data points (for each destination). We first show the scatter plots using all available destinations, with symbol weights proportional to the number of available firm observations, and then again dropping any destination with fewer than 250 exporting firms.[29] Those scatter plots show a very strong positive correlation between the export share ratios and the measures of toughness of competition in the destination. Absent any variations in the toughness of competition across destinations – such as in a world with monopolistic competition and C.E.S. preferences where markups are exogenously fixed – the variation in the relative export shares should be white noise. The data show that variations in competition (at least as proxied by country size and supplier potential) is strong enough to induce large variations in the firms' relative export sales across destinations. Scatter plots for the local ratio and Theil index look surprisingly similar.

We now turn to our regression analysis using the three skewness measures. Each observation summarizes the skewness of export sales for a given firm to a given destination. Since we seek to uncover variation in that skewness for a given firm, we include firm fixed effects throughout.

[27] Redding and Venables (2004) show that this construction for supply potential (and the similar one for market potential) is also consistent with its theoretical counterpart in a Dixit-Stiglitz-Krugman model. They construct those measures for a cross-section of 100 countries in 1994. Mayer (2008) uses the same methodology to cover more countries and a longer time period.

[28] As is the case with market potential, a country's supplier potential is strongly correlated with that country's GDP: big trading economies tend to be located near one-another. The supply potential data is available online at http://www.cepii.fr/anglaisgraph/bdd/marketpotentials.htm

[29] Increasing that cutoff level for the number of exporters slightly increases the fit and slope of the regression line through the scatter plot.

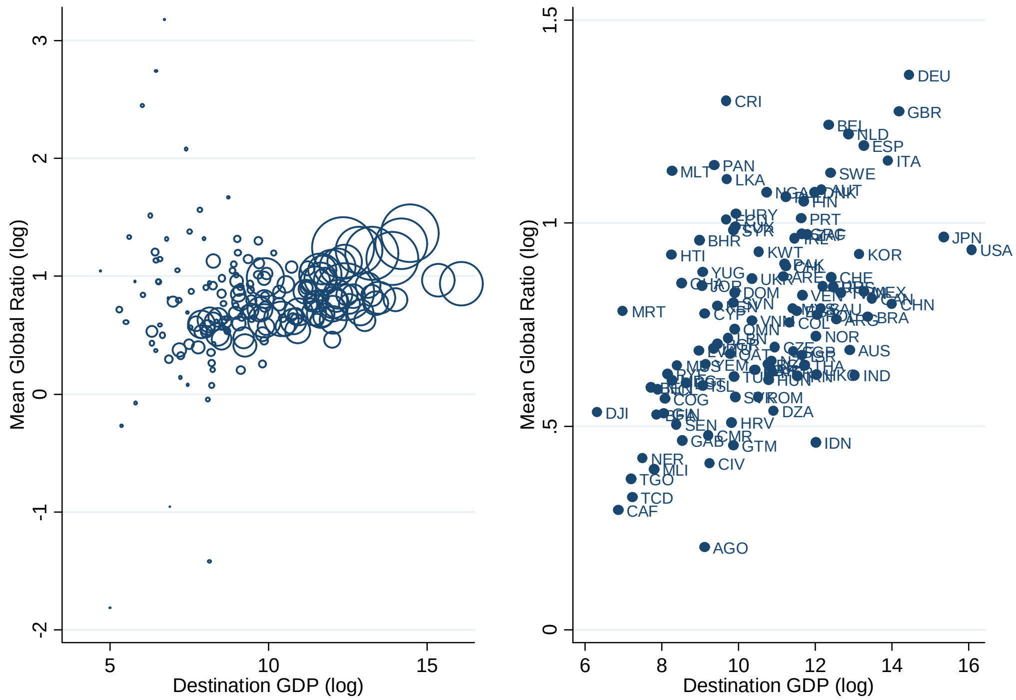

Figure 2: Mean Global Ratio and Destination Country GDP

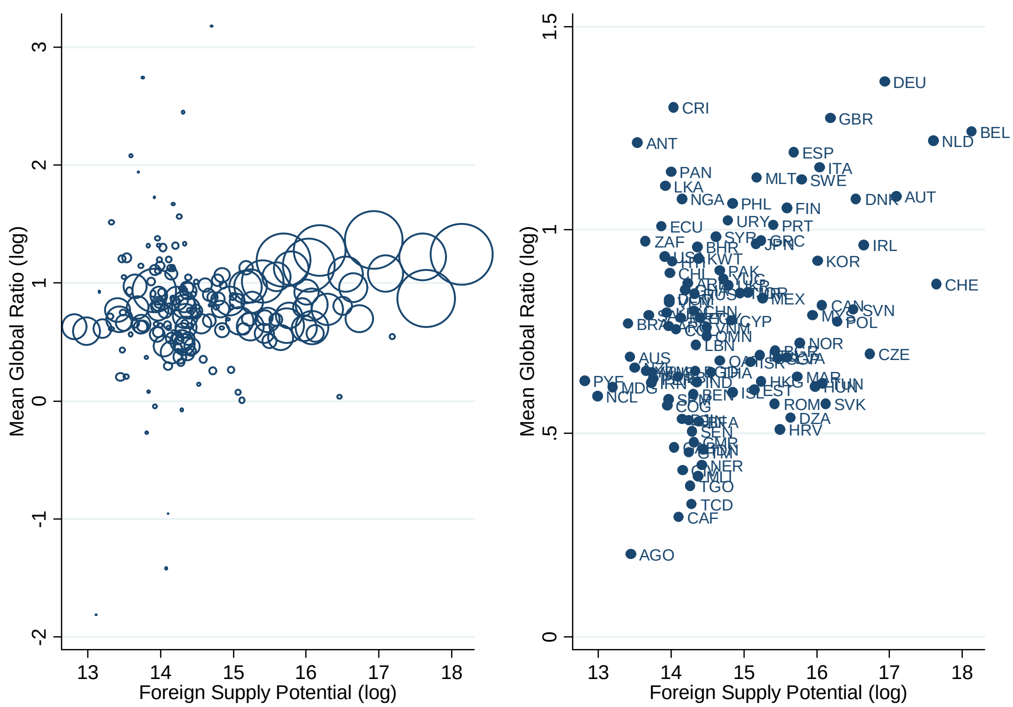

Figure 3: Mean Global Ratio and Destination Supply Potential

We use destination specific controls for both competition (GDP and supplier potential, both in logs) and for the bilateral trade barriers with France (distance in logs, and the common language indicator). We report the results using the global sales ratio in Table 1, and those using the local ratio in Table 2.

Table 1: Global ratio of core product ($m = 0$) to m' product sales' regressions

	(1)	(2)	(3)	(4)	(5)
ln GDP	0.060***	0.077***	0.071***	0.059***	0.051***
	(0.007)	(0.014)	(0.008)	(0.010)	(0.008)
ln supply potential	0.007	0.015	0.026*	0.016	-0.005
	(0.014)	(0.024)	(0.015)	(0.018)	(0.015)
ln distance	-0.097***	-0.111***	-0.103***	-0.124***	-0.101***
	(0.019)	(0.032)	(0.020)	(0.023)	(0.020)
common language	-0.073***	-0.100**	-0.117***	-0.132***	-0.067**
	(0.028)	(0.042)	(0.030)	(0.036)	(0.028)
ln GDP per cap					0.032***
					(0.012)
$m' =$	1	2	1	1	1
Destination GDP/cap	all	all	top 50%	top 20%	all
Observations	68809	32859	64892	53723	68797
R^2	0.006	0.008	0.006	0.005	0.006

Note: Firm-level fixed effects for all columns. Standard errors in parentheses.
Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In each table, the first column uses the ratio of the best to next best product, while the second column uses the ratio of the best to third best product. The next two columns return to the initial ratio (best to second best), and progressively select country destinations with income levels above a threshold. Column 3 excludes all countries below the median income level, while column 4 only selects destinations in the top 20% of the cross-country income distribution.[30] The results using the Theil index are reported in Table 3, with columns 2-3 representing the same selection by destination country income as in the previous two tables. Since the measure of skewness can be mechanically affected by the number of observations used to compute it (especially when those numbers are very low), we also control directly for that number in the regressions (the number of products exported by that firm to that destination).

All three tables strongly confirm the important and significant impact of destination country

[30] Since French firms ship disproportionately more goods to countries with higher incomes, the number of observations drops very slowly with the number of excluded country destinations.

Table 2: Local ratio of core product ($m = 0$) to m' product sales' regressions

	(1)	(2)	(3)	(4)	(5)
ln GDP	0.033***	0.045***	0.039***	0.012***	0.024***
	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)
ln supply potential	0.026***	0.047***	0.038***	0.049***	0.014**
	(0.005)	(0.008)	(0.006)	(0.007)	(0.006)
ln distance	-0.093***	-0.102***	-0.096***	-0.100***	-0.098***
	(0.008)	(0.011)	(0.008)	(0.009)	(0.008)
common language	-0.182***	-0.285***	-0.223***	-0.294***	-0.177***
	(0.010)	(0.015)	(0.011)	(0.015)	(0.010)
ln GDP per cap					0.031***
					(0.004)
$m' =$	1	2	1	1	1
Destination GDP/cap	all	all	top 50%	top 20%	all
Observations	151017	96672	138019	106129	150992
R^2	0.017	0.025	0.014	0.012	0.018

Note: Firm-level fixed effects for all columns. Standard errors in parentheses.
Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

size on the within-firm measure of export skewness: a French firm sells relatively more of its best performing products to bigger country destinations. This effect is also economically significant. If the Czech Republic's GDP were equal to German GDP (an increase from the 75% to 99% percentile in the world GDP distribution), then French firms would respond by increasing the relative shipment of their best global product (relative to their second best global product) from a ratio of 2 to 2.48. The effect of geography, via supply potential, is also highly significant in explaining relative exports sales based on their destination-specific ranking. This holds for all columns in Table 2 for the local ratio. The effect on the Theil skewness measure is also significant, but only when the sample of destination countries is restricted to those with relatively higher levels of income. Lastly, the effect of supply potential does not have a significant impact on the global ranking. This may be due in part to higher level of noise in this measure, and the fact that supply potential is strongly correlated with GDP (the correlation is .5).

The last column in all three tables adds GDP per capita as an additional regressor. We do this to control for differences in preferences across countries (outside the scope of our theoretical model) tied to product quality and consumer income. In particular, we want to allow consumer income to bias consumption towards higher quality varieties. If within-firm product quality is negatively

Table 3: Theil index regressions

	(1)	(2)	(3)	(4)
# products	0.027***	0.026***	0.026***	0.027***
	(0.001)	(0.001)	(0.001)	(0.001)
ln GDP	0.051***	0.057***	0.055***	0.045***
	(0.001)	(0.001)	(0.002)	(0.001)
ln supply potential	0.002	0.011***	0.011***	-0.007***
	(0.002)	(0.002)	(0.003)	(0.002)
ln distance	-0.072***	-0.077***	-0.091***	-0.075***
	(0.003)	(0.003)	(0.003)	(0.003)
common language	0.003	-0.022***	-0.047***	0.006
	(0.004)	(0.004)	(0.006)	(0.004)
ln GDP per cap				0.022***
				(0.002)
Destination GDP/cap	all	top 50%	top 20%	all
Observations	96684	89585	70791	96670
R^2	0.365	0.354	0.332	0.366

Note: Firm-level fixed effects for all columns. Standard errors in parentheses. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

related to its distance from the core product, then this would induce a positive correlation between consumer income and the within-firm skewness of expenditure shares. Our empirical results (in the last column of all three tables) strongly support this hypothesis.[31] Nevertheless, we still find a very strong effect of competition, now captured by the independent contribution of country population (the coefficient for log GDP, when controlling for log GDP per capita), on the skewness of within-firm export sales. Measuring the independent contribution of geography now becomes more problematic as the same forces that generate a link between geography and increased competition are also most likely the same ones that are also reflected in higher GDP per capita.[32]

We now turn to the effects of bilateral trade barriers and enhancers. All three tables show that both distance and a common language have a strong significant impact on the skewness of the firms' export sales. Interestingly, those effects go in opposite direction: a language barrier (French is not spoken in the destination country) increases the skewness of export sales while the distance barrier reduces the skewness. As previously argued, this implies that the language barrier generates either

[31] Consumer income could also have an independent effect on competition, with ambiguous consequences on that skewness measure.

[32] Redding and Venables (2004) and Mayer (2008) find strong empirical confirmation for this effect.

proportional or increasing trade costs along the product ladder while distance generates trade costs that are decreasing along the product ladder. This effect of distance is thus consistent with specific trade costs. This seems particularly likely for the effects of distance related costs *within* a firm's product range. A better performing product will likely not be much more costly to ship than a worse performing one – inducing costs that increase less than proportionally along the product ladder.

6 Conclusion

In this paper, we have developed a model of multi-product firms that highlights how differences in market size and geography affect the within-firm distribution of export sales across destinations. This effect on the firms' product mix choice is driven by variations in the toughness of competition across markets captured by downward shifts in the distribution of markups across products. We test these predictions for a comprehensive set of French exporters, and find that market size and geography indeed have a very strong impact on their product mix choice across world destinations. In particular, French firms skew their export sales towards better performing products in big destination markets, and markets where many exporters from around the world compete (high foreign supply potential markets). We take this as a strong indication that differences in the toughness of competition across export markets generate substantial responses in firm-level markups indirectly revealed by pronounced changes in the skewness of export sales. Trade models based on exogenous markups cannot explain this strong significant link between those destination market characteristics and the within-firm skewness of export sales (after controlling for bilateral trade costs). Theoretically, this within firm change in product mix driven by the trading environment has important repercussions on firm productivity – and can explain the observed link between trade liberalization and productivity improvement within firms. Lastly, we also find evidence that language differences generate trade costs that increase at least proportionally over a firm's product ladder while distance generates trade costs that increase less than proportionally over that same product ladder.

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