Market Size, Trade, and Productivity

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ABSTRACT

We develop a monopolistically competitive model of trade with firm heterogeneity - in terms of productivity differences - and endogenous differences in the 'toughness' of competition across markets - in terms of the number and average productivity of competing firms. We analyze how these features vary across markets of different size that are not perfectly integrated through trade; we then study the effects of different trade liberalization policies. In our model, market size and trade affect the toughness of competition, which then feeds back into the selection of heterogeneous producers and exporters in that market. Aggregate productivity and average markups thus respond to both the size of a market and the extent of its integration through trade (larger, more integrated markets exhibit higher productivity and lower markups). Our model remains highly tractable, even when extended to a general framework with multiple asymmetric countries integrated to different extents through asymmetric trade costs. We believe this provides a useful modeling framework that is particularly well suited to the analysis of trade and regional integration policy scenarios in an environment with heterogeneous firms and endogenous markups.

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1 Introduction

We develop a monopolistically competitive model of trade with heterogeneous firms and endogenous differences in the 'toughness' of competition across countries. Firm heterogeneity – in the form of productivity differences – is introduced in a similar way to Melitz (2003): firms face some initial uncertainty concerning their future productivity when making a costly and irreversible investment decision prior to entry. However, we further incorporate endogenous markups using the linear demand system with horizontal product differentiation developed by Ottaviano, Tabuchi, and Thisse (2002). This generates an endogenous distribution of markups across firms that responds to the toughness of competition in a market – the number and average productivity of competing firms in that market. We analyze how these features vary across markets of different size that are not perfectly integrated through trade and then study the effects of different trade liberalization policies.

In our model, market size and trade affect the toughness of competition in a market, which then feeds back into the selection of heterogeneous producers and exporters in that market. Aggregate productivity and average markups thus respond to both the size of a market and the extent of its integration through trade (larger, more integrated markets exhibit higher productivity and lower markups). Our model remains highly tractable, even when extended to a general framework with multiple asymmetric countries integrated to different extents through asymmetric trade costs. We believe this provides a useful modeling framework that is particularly well suited to the analysis of trade and regional integration policy scenarios in an environment with heterogeneous firms and endogenous markups.

We first introduce a closed economy version of our model. In a key distinction from Melitz (2003), market size induces important changes in the equilibrium distribution of firms and their performance measures. Bigger markets exhibit higher levels of product variety and host more productive firms that set lower markups (hence lower prices). These firms are bigger (in terms of both output and sales) and earn higher profits (although average markups are lower), but face a lower probability of survival at entry.[1] We discuss how our comparative statics results for the effects of market size on the distribution of firm-level performance measures accord well with the evidence for U.S. establishments across regions. We then present the open economy version of the

[1] This closed economy version of our model is related to Asplund and Nocke (2006), which analyzes firm dynamics in a closed economy. They obtain similar results linking higher firm churning rates with larger markets – and provide supporting empirical evidence. On the other hand, the increased tractability afforded by our model yields additional important comparative static predictions for this closed economy case.

model. We focus on a two country case but show in the appendix how this setup can be extended to multiple asymmetric countries. We show how costly trade does not completely integrate markets and thus does not obviate the effects of market size differences across trading partners: the bigger market still exhibits larger and more productive firms as well as more product variety, lower prices, and lower markups.

Our model's predictions for the effects of bilateral trade liberalization are very similar to those emphasized in Melitz (2003): trade forces the least productive firms to exit and reallocates market shares towards more productive exporting firms (lower productivity firms only serve their domestic market).[2] Our model also explains other empirical patterns linking the extent of trade barriers to the distribution of productivity, prices, and markups across firms. In an important departure from Melitz (2003), our model exhibits a link between bilateral trade liberalization and reductions in markups, thus highlighting the potential pro-competitive effects often associated with episodes of trade liberalization. We then analyze the effects of asymmetric liberalization. We consider the case of unilateral liberalization in a two country world and that of preferential liberalization in a three country world. Although the liberalizing countries always gain from the pro-competitive effects of increased import competition in the short run, we show that these gains may be overturned in the long run due to shifts in the pattern of entry.

The channels for all these welfare effects, stemming from both multilateral and unilateral liberalization, have all been previously identified in the early 'new trade theory' literature emphasizing imperfect competition with representative firms. However, these contributions used very different modeling structures (monopolistic competition with product differentiation versus oligopoly with a homogeneous good, free entry versus a fixed number of firms) in order to isolate one particular welfare channel. The main contribution of our modeling approach is that it integrates all of these welfare channels into a single, unified (yet highly tractable) framework, while simultaneously incorporating the important selection and reallocation effects among heterogeneous firms that were previously emphasized. Krugman (1979) showed how trade can induce pro-competitive effects in a model with monopolistic competition and endogenous markups while Markusen (1981) formalized and highlighted the pro-competitive effects from trade due to the reduction in market power of a domestic monopolist. This latter modeling framework was then extended by Horstmann and

[2] Micro-econometric studies strongly confirm these selection effects of trade (both according to firm export status, and for the effects of trade liberalization). See, among others, Aw, Chung, and Roberts (2000), Bernard and Jensen (1999), Clerides, Lach, and Tybout (1998), Pavcnik (2002), Bernard, Jensen, and Schott (2006), and the survey in Tybout (2002).

Markusen (1986) and Venables (1985) to the case of oligopoly with free entry (while maintaining the assumption of a homogeneous traded good). These papers emphasized, among other things, how free entry could generate welfare losses for a country unilaterally liberalizing imports – by 'reallocating' firms towards the country's trading partners. Venables (1987) showed how this effect also can be generated in a model with monopolistic competition and product differentiation with exogenous markups. Our model isolates this asymmetric effect of unilateral trade liberalization induced by entry by also considering a short run response to liberalization, where the additional entry of firms is restricted. Of course, our model also features the now standard welfare gains from additional product variety as well as the asymmetric welfare gains of trade induced by differences in country size and trade costs highlighted by Krugman (1980). Again, we emphasize that our contribution is not to highlight a new welfare channel but rather to show how all of these welfare channels can jointly be analyzed within a single framework that additionally captures the welfare effects stemming from changes in average productivity based on the selection of heterogenous firms into domestic and export markets.

Our paper is also related to a much more recent literature emphasizing heterogenous firms and endogenous markups, resulting in a non-degenerate distribution of markups across firms. These models all generate the equilibrium property that more productive firms charge higher markups. Bernard et al. (2003) also incorporate firm heterogeneity and endogenous markups into an open economy model. However, in their model, the distribution of markups is invariant to country characteristics and to geographic barriers. Asplund and Nocke (2006) investigate the effect of market size on the entry and exit rates of heterogeneous firms. They analyze a stochastic dynamic model of a monopolistically competitive industry with linear demand and hence variable markups. They consider, however, a closed economy, so they do not provide any results concerning the role of geography and partial trade liberalization. In this paper, we focus instead on the response of the markups to country characteristics and to geographic barriers and their feedback effects on firm selection. Most importantly, we show how our model can be extended to an open economy equilibrium with multiple countries, including the analysis of asymmetric trade liberalization scenarios.

The paper is organized in four additional sections after the introduction. The first presents and solves the closed economy model. The second derives the two-country model and studies the effects of international market size differences. The third investigates the impacts of trade liberalization considering both bilateral and unilateral experiments. This includes a three-country version of the model that highlights the effects of preferential trade agreements. The last section concludes.

2 Closed Economy

Consider an economy with L consumers, each supplying 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

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

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 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:

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

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

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

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 N 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.[3]

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

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

where I^c is the consumer's income and $\sigma_p^2 = (1/N)\int_{i\in\Omega^*}(p_i - \bar{p})^2\,di$ represents the variance of prices. To ensure positive demand levels for the numeraire, we assume that $I^c > \int_{i\in\Omega^*} p_i q_i^c di = \bar{p}Q^c - N\sigma_p^2/\gamma$. 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 product variety N.

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 exhibits constant returns to scale at marginal cost c (equal to unit labor requirement).[4] 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 $[0, c_M]$. Since the entry cost is sunk, firms that can

[3] 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.

[4] For simplicity, we do not model any overhead production costs. This would significantly degrade the tractability of our model without adding any new insights. In our model with bounded marginal utility, high cost firms will not survive, even without such fixed costs.

cover their marginal cost survive and produce. All other firms exit the industry. Surviving firms maximize their profits using the residual demand function (3). In so doing, given the continuum of competitors, a firm takes the average price level $\bar{p}$ and number of firms N as given. This is the monopolistic competition outcome.

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

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

The profit maximizing price $p(c)$ may be above the price bound $p_{\max}$ from (4), in which case the firm exits. Let c_D reference the cost of the firm who is just indifferent about remaining in the industry. This firm earns zero profit as its price is driven down to its marginal cost, $p(c_D) = c_D = p_{\max}$, and its demand level $q(c_D)$ is driven to zero. We assume that c_M is high enough to be above c_D, so that some firms with cost draws between these two levels exit. All firms with cost $c < c_D$ earn positive profits (gross of the entry cost) and remain in the industry. The threshold cost c_D summarizes the effects of both the average price and number of firms on the performance measures of all firms. Let $r(c) = p(c)q(c)$, $\pi(c) = r(c) - q(c)c$, $\mu(c) = p(c) - c$ denote the revenue, profit, and (absolute) markup of a firm with cost c. All these performance measures can then be written as functions of c and c_D only:

$$\begin{aligned}
p(c) &= \frac{1}{2}\left(c_D + c\right), && (7)\\
\mu(c) &= \frac{1}{2}\left(c_D - c\right), && (8)\\
q(c) &= \frac{L}{2\gamma}\left(c_D - c\right), && (9)\\
r(c) &= \frac{L}{4\gamma}\left[\left(c_D\right)^2 - c^2\right], && (10)\\
\pi(c) &= \frac{L}{4\gamma}\left(c_D - c\right)^2. && (11)
\end{aligned}$$

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

2.3 Free Entry Equilibrium

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. Using (11), this yields the equilibrium free entry condition

$$\int_0^{c_D} \pi(c)dG(c) = \frac{L}{4\gamma} \int_0^{c_D} (c_D - c)^2 \, dG(c) = f_E, \tag{12}$$

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

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

This yields the zero cutoff profit condition:

$$N = \frac{2\gamma}{\eta} \frac{\alpha - c_D}{c_D - \bar{c}}, \tag{13}$$

where $\bar{c} = \left[\int_0^{c_D} c dG(c)\right] / G(c_D)$ is the average cost of surviving firms.[5] The number of entrants is then given by $N_E = N/G(c_D)$.

Given a production technology referenced by $G(c)$, average productivity will be higher (lower $\bar{c}$) when sunk costs are lower, when varieties are closer substitutes (lower γ), and in bigger markets (more consumers L). In all these cases, firm exit rates are also higher (the pre-entry probability of survival $G(c_D)$ is lower). The demand parameters α and η that index the overall level of demand for the differentiated varieties (relative to the numeraire) do not affect the selection of firms and industry productivity – they only affect the equilibrium number of firms. Competition is 'tougher' in larger markets as more firms compete and average prices $\bar{p} = (c_D + \bar{c})/2$ are lower. A firm with cost c responds to this tougher competition by setting a lower markup (relative to the markup it would set in a smaller market – see (8)).

2.4 Parametrization of Technology

All the results derived so far hold for any distribution of 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 productivity draws $1/c$ follow a Pareto distribution with lower produc-

[5] Given (7), it is readily verified that $\bar{p} = (c_D + \bar{c})/2$.

tivity bound $1/c_M$ and shape parameter $k \geq 1$.[6] This implies a distribution of cost draws c given by

$$G(c) = \left(\frac{c}{c_M}\right)^k, \ c \in [0, c_M]. \tag{14}$$

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 $G_D(c) = (c/c_D)^k, \ c \in [0, c_D]$.

Given this parametrization, the cutoff cost level c_D determined by (12) is then

$$c_D = \left[\frac{2(k+1)(k+2)\gamma\,(c_M)^k\, f_E}{L}\right]^{\frac{1}{k+2}}, \tag{15}$$

where we assume that $c_M > \sqrt{[2(k+1)(k+2)\gamma f_E]\,/L}$ in order to ensure that $c_D < c_M$ as was previously anticipated. The number of surviving firms, determined by (13), is then:

$$N = \frac{2(k+1)\gamma}{\eta}\frac{\alpha - c_D}{c_D}. \tag{16}$$

This parametrization also yields simple derivations for the averages of all the firm-level performance

[6] Del Gatto, Mion and Ottaviano (2006) estimate the distribution of total factor productivity using firm-level data for a panel of 11 EU countries and 18 manufacturing sectors. They find that the Pareto distribution provides a very good fit for firm productivity across sectors and countries. The average k is estimated to be close to 2. Combes et al. (2007) extend our model and consider general cost/productivity distributions. They show how our main comparative static results do not depend on our choice of parametrization.

measures described in (7)-(11):[7]

$$\bar{c} = \frac{k}{k+1} c_D, \qquad \bar{q} = \frac{L}{2\gamma} \frac{1}{k+1} c_D = \frac{(k+2)(c_M)^k}{(c_D)^{k+1}} f_E,$$
$$\bar{p} = \frac{2k+1}{2k+2} c_D, \qquad \bar{r} = \frac{L}{2\gamma} \frac{1}{k+2} (c_D)^2 = \frac{(k+1)(c_M)^k}{(c_D)^k} f_E,$$
$$\bar{\mu} = \frac{1}{2} \frac{1}{k+1} c_D, \qquad \bar{\pi} = f_E \frac{(c_M)^k}{(c_D)^k}.$$

As with the cost average $\bar{c}$, the average for a performance measure $z(c)$ is given by $\bar{z} = \left[\int_0^{c_D} z(c) dG(c)\right] / G(c_D)$. Although $\bar{c}$ is computed as the unweighted average of firm cost, it provides an index to a much broader set of inverse productivity measures. The average of firm productivity $1/c$ - whether unweighted, weighted by revenue $r(c)$, or weighted by output $q(c)$ - is proportional to $1/\bar{c}$ (and hence to $1/c_D$). In the appendix, we further show how the variances of all the firm performance measures can be written as simple functions of the variance of the cost draws. 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):

$$U = 1 + \frac{1}{2\eta} (\alpha - c_D) \left(\alpha - \frac{k+1}{k+2} c_D \right). \tag{17}$$

Welfare increases with decreases in the cutoff c_D, as the latter induces increases in product variety N as well as decreases in the average price $\bar{p}$ (these effects dominate the negative impact of the lower price variance).[8]

We previously mentioned that bigger markets induced tougher selection (lower cutoff c_D), leading to higher average productivity (lower $\bar{c}$) and lower average prices. In addition, under our assumed parametrization of cost draws, average firm size (both in terms of output and sales) and profits are higher in larger markets: the direct market size effect outweighs its indirect effect through lower prices and markups. Similarly, average markups are lower as the direct effect of increased competition on firm-level markups ($\mu(c)$ shifts down) outweighs the selection effect on firms with lower cost (and relatively higher markups). We also note that average profits and sales increase

[7] All derivations are based on the assumption that consumers have positive demands for the numeraire good. Consumers derive all of their income from their labor: there are no redistributed firm profits as industry profits (net of the entry costs) are zero. We therefore need to ensure that each consumer spends less than this unit income on the differentiated varieties. Spending per consumer on the varieties is $N\bar{r}/L = (\alpha - c_D) c_D (k+1) / [\eta (k+2)]$. A sufficient condition for this to be less than 1 is $\alpha < 2\sqrt{\eta (k+2) / (k+1)}$.

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

by the same proportion when market size increases. Thus, average industry profitability $\bar{\pi}/\bar{r}$ does not vary with market size. Finally, we note that our technology parametrization also allows us to unambiguously sign the effects of market size on the dispersion of the firm performance measures: the variance of cost, prices, and markups are lower in bigger markets (the selection effect decreases the support of these distributions for any distribution $G(c)$); on the other hand, the variance of firm size (in terms of either output or revenue) is larger in bigger markets due to the direct magnifying effect of market size on these variables.

These comparative statics for the effects of market size on the mean and variance of firm performance measures accord well with the empirical evidence for U.S. establishments/plants (across regions) reported by Campbell and Hopenhayn (2005) and Syverson (2004, forthcoming). These studies focus on sectors (retail, concrete, cement) where U.S. regional markets are relatively closed – and focus on the effects of U.S. market size (across regions) on the distribution of U.S. establishments. Campbell and Hopenhayn (2005) report that retail establishments in larger markets exhibit higher sales and employment, and find weaker evidence that these distributions are more disperse. Syverson(2004, forthcoming) focuses on sectors where physical output can be measured along with sales (and hence prices recovered). He finds similar evidence of larger average plant size in larger markets along with higher average plant productivity. He finds further support for the tougher selection effect in the larger markets: the distribution of productivity is less disperse, with a higher lower bound for the productivity distribution. These effects also show up in the distribution of plant level prices: average prices are lower in bigger markets, while the dispersion is reduced.

2.5 A Short-Run Equilibrium

In the following sections, we introduce an open economy version of our model and analyze the consequences of various trade liberalization scenarios. The asymmetric liberalization scenarios induce a well-known relocation of firms (entrants in our model) across countries. We will then want to separate these 'long-run' effects from the direct 'short-run' effects of liberalization on competition and selection across markets. Towards this goal, we introduce a short-run version of our model. For now, we describe its main features and equilibrium characteristics in the closed economy.

Up to this point, we have considered a long-run scenario where entry and exit decisions were endogenously determined. In contrast, the short-run is characterized by a fixed number and distribution of incumbents. In this time frame, these incumbents decide whether they should operate and produce – or shut down. If so, they can restart production without incurring the entry cost

again. No entry is possible in the short-run.

Let $\bar{N}$ denote the fixed number of incumbents and $\bar{G}(c)$ their cost distribution with support $[0, \bar{c}_M]$. We maintain our Pareto parametrization assumption for productivity $1/c$, implying $\bar{G}(c) = (c/\bar{c}_M)^k$. As was the case in the long-run, only firms earning non-negative profits produce. This leads to the same determination of the cost cutoff c_D. Firms with cost $c > c_D$ shut down and the remaining $N = \bar{N}\bar{G}(c_D) = \bar{N}\,(c_D/\bar{c}_M)^k$ firms produce. If the least productive firm with cost $\bar{c}_M$ earns non-negative profits, then $c_D = \bar{c}_M$ and all firms produce in the short-run. Otherwise, the cutoff c_D is determined by the zero cutoff profit condition (13):

$$N = \frac{2\gamma}{\eta}\frac{\alpha - c_D}{c_D - \bar{c}} = \frac{2\,(k+1)\,\gamma}{\eta}\frac{\alpha - c_D}{c_D}, \qquad \text{whenever } c_D < \bar{c}_M,$$

since the average cost of producing firms is still $\bar{c} = [k/\,(k+1)]\,c_D$ as in the long-run equilibrium. Using the new condition for the number of firms $N = \bar{N}\,(c_D/\bar{c}_M)^k$, the zero cutoff profit condition yields

$$\frac{(c_D)^{k+1}}{\alpha - c_D} = \frac{2\,(k+1)\,\gamma\,(\bar{c}_M)^k}{\eta\bar{N}}, \qquad \text{whenever } c_D < \bar{c}_M,$$

which uniquely identifies the short-run cutoff c_D and the number of producing firms N.

In this short-run equilibrium, changes in market size do not induce any changes in the distribution of producing firms (c_D remains constant), nor in the distribution of prices and markups (see (7) and (8)). All firms adjust their output levels in proportion to the market size change.[9] Only entry in the long run induces inter-firm reallocations (and the associated change in the cutoff c_D).

3 Open Economy

In the previous section we used a closed economy model to assess the effects of market size on various performance measures at the industry level. This closed economy model could be immediately applied to a set of open economies that are perfectly integrated through trade. In this case, the transition from autarky to free trade is equivalent to an increase in market size – which would induce increases in average productivity and product variety, and decreases in average markups. However, the closed-economy scenario can not be readily extended to the case of goods that are not freely traded. Furthermore, although trade is costly, it nevertheless connects markets in ways

[9] When market size changes, the residual inverse demand curve rotates around the same price bound $p_{\max}$. With linear demand curves, the marginal revenue curve rotates in such a way that the profit maximizing price for any given marginal cost remains unchanged.

that preclude the analysis of each market in isolation. To understand these inter-market linkages, we now extend our model to a two-country setting. In the appendix, we show how our framework can be extended to an arbitrary number of countries and trade cost patterns (including arbitrary asymmetric costs).

Consider two countries, H and F, with L^H and L^F consumers in each country. Consumers in both countries share the same preferences, leading to the inverse demand function (2). The two markets are segmented, although firms can produce in one market and sell in the other, incurring a per-unit trade cost.[10] Specifically, the delivered cost of a unit with cost c to country l ($l = H, F$) is $\tau^l c$ where $\tau^l > 1$. Thus, we allow countries to differ along two dimensions: market size L^l and barriers to imports τ^l.

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

$$p^l = \frac{1}{\eta N^l + \gamma}\left(\gamma\alpha + \eta N^l \bar{p}^l\right), \quad l = H, F, \tag{18}$$

where N^l is the total number of firms selling in country l (the total number of domestic firms and foreign exporters) and $\bar{p}^l$ is the average price (across both local and exporting firms) in country l. Let $p^l_D(c)$ and $q^l_D(c)$ represent the domestic levels of the profit maximizing price and quantity sold for a firm producing in country l with cost c. Such a firm may also decide to produce some output $q^l_X(c)$ that it exports at a delivered price $p^l_X(c)$.

Since the markets are segmented and firms produce under constant returns to scale, they independently maximize the profits earned from domestic and exports sales. Let $\pi^l_D(c) = \left[p^l_D(c) - c\right] q^l_D(c)$ and $\pi^l_X(c) = \left[p^l_X(c) - \tau^h c\right] q^l_X(c)$ denote the maximized value of these profits as a function of the firm's marginal cost c (where $h \neq l$).[11] Analogously to (6), the profit maximizing prices and output levels must satisfy: $q^l_D(c) = \left(L^l/\gamma\right)\left[p^l_D(c) - c\right]$ and $q^l_X(c) = \left(L^h/\gamma\right)\left[p^l_X(c) - \tau^h c\right]$. As was the case in the closed economy, only firms earning non-negative profits in a market (domestic or export) will choose to sell in that market. This leads to similar cost cutoff rules for firms selling in either market. Let c^l_D denote the upper bound cost for firms selling in their domestic market, and let c^l_X

[10] We later show how our equilibrium conditions rule out any profitable arbitrage opportunities. For simplicity, we do not model any fixed export costs. This would significantly degrade the tractability of our model without adding any new insights. In our model with bounded marginal utility, per-unit costs alone are enough to induce selection into export markets.

[11] Throughout this analysis, all derivations involving l and h hold for $l = H, F$ and $h \neq l$.

denote the upper bound cost for exporters from l to h. These cutoffs must then satisfy:

$$\begin{aligned} c_D^l &= \sup\left\{c : \pi_D^l(c) > 0\right\} = p_{\max}^l, \\ c_X^l &= \sup\left\{c : \pi_X^l(c) > 0\right\} = \frac{p_{\max}^h}{\tau^h}. \end{aligned} \tag{19}$$

This implies $c_X^h = c_D^l/\tau^l$: trade barriers make it harder for exporters to break even relative to domestic producers.

As was the case in the closed economy, the cutoffs summarize all the effects of market conditions relevant for firm performance. In particular, the optimal prices and output levels can be written as functions of the cutoffs:

$$\begin{aligned} p_D^l(c) &= \frac{1}{2}\left(c_D^l + c\right), \qquad & q_D^l(c) &= \frac{L^l}{2\gamma}\left(c_D^l - c\right), \\ p_X^l(c) &= \frac{\tau^h}{2}(c_X^l + c), \qquad & q_X^l(c) &= \frac{L^h}{2\gamma}\tau^h\left(c_X^l - c\right), \end{aligned} \tag{20}$$

which yield the following maximized profit levels:

$$\begin{aligned} \pi_D^l(c) &= \frac{L^l}{4\gamma}\left(c_D^l - c\right)^2, \\ \pi_X^l(c) &= \frac{L^h}{4\gamma}\left(\tau^h\right)^2\left(c_X^l - c\right)^2. \end{aligned} \tag{21}$$

3.1 Free Entry Condition

Entry is unrestricted in both countries. Firms choose a production location prior to entry and paying the sunk entry cost. In order to focus our analysis on the effects of market size and trade costs differences, we assume that countries share the same technology – referenced by the entry cost f_E and cost distribution $G(c)$.[12] Free entry of domestic firms in country l implies zero expected profits in equilibrium, hence:

$$\int_0^{c_D^l} \pi_D^l(c)dG(c) + \int_0^{c_X^l} \pi_X^l(c)dG(c) = f_E.$$

[12] We relax this assumption in the appendix and investigate the implications of Ricardian comparative advantage.

We also assume the same Pareto parametrization (14) for the cost draws $G(c)$ in both countries. Given (21), the free entry condition can be re-written:

$$L^l \left(c_D^l\right)^{k+2} + L^h \left(\tau^h\right)^2 \left(c_X^l\right)^{k+2} = \gamma\phi, \tag{22}$$

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.

This free entry condition will hold so long as there is a positive mass of domestic entrants $N_E^l > 0$ in country l.[13] In this paper, we focus on the case where both countries produce the differentiated good and $N_E^l > 0$ for $l = H, F$. Then, since $c_X^h = c_D^l/\tau^l$, the free entry condition (22) can be re-written

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

where $\rho^l \equiv \left(\tau^l\right)^{-k} \in (0,1)$ is an inverse measure of trade costs (the 'freeness' of trade). This system (for $l = H, F$) can then be solved for the cutoffs in both countries:

$$c_D^l = \left[\frac{\gamma\phi}{L^l}\frac{1-\rho^h}{1-\rho^l\rho^h}\right]^{\frac{1}{k+2}}. \tag{23}$$

3.2 Prices, Product Variety, and Welfare

The prices in country l reflect both the domestic prices of country-l firms, $p_D^l(c)$, and the prices of exporters from h, $p_X^h(c)$.Using (19) and (20), these prices can be written:

$$\begin{aligned} p_D^l(c) &= \frac{1}{2}\left(p_{\max}^l + c\right),\ c \in [0, c_D^l], \\ p_X^h(c) &= \frac{1}{2}\left(p_{\max}^l + \tau^l c\right),\ c \in [0, c_D^l/\tau^l], \end{aligned}$$

where $p_{\max}^l$ is the price threshold defined in (18).In addition, the cost of domestic firms $c \in [0, c_D^l]$ and the delivered cost of exporters $\tau^l c \in [0, c_D^l]$ have identical distributions over this support, given by $G^l(c) = \left(c/c_D^l\right)^k$. The price distribution in country l of domestic firms producing in l, $p_D^l(c)$, and exporters producing in h, $p_X^h(c)$, are therefore also identical. The average price in country l is thus given by

$$\bar{p}^l = \frac{2k+1}{2k+2}c_D^l.$$

[13] Otherwise, $\int_0^{c_D^l} \pi_D^l(c)dG(c) + \int_0^{c_X^l} \pi_X^l(c)dG(c) < f_E$, $N_E^l = 0$, and country l specializes in the numeraire. For the sake of parsimony, we rule out this case by assuming that α is large enough.

Combining this with the threshold price in (18) determines the number of firms selling in country l:

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

These results for product variety and average prices are identical to the closed economy case. This is driven by the matching price distributions of domestic firms and exporters in that market. Thus, welfare in country l can be written in an identical way to (17) as:

$$U^l = 1 + \frac{1}{2\eta}\left(\alpha - c_D^l\right)\left(\alpha - \frac{k+1}{k+2}c_D^l\right). \tag{25}$$

Once again, welfare changes monotonically with the domestic cost cutoff, which captures the dominant effects of product variety and average prices.[14]

3.3 Number of Entrants, Producers, and Exporters

The number of sellers (also indexing product variety) in country l is comprised of domestic producers and exporters from h. Given a positive mass of entrants N_E^l in both countries, there are $G(c_D^l)N_E^l$ domestic producers and $G(c_X^h)N_E^h$ exporters selling in l satisfying $G(c_D^l)N_E^l + G(c_X^h)N_E^h = N^l$. This condition (holding for each country) can be solved for the number of entrants in each country:

$$\begin{aligned} N_E^l &= \frac{(c_M)^k}{1-\rho^l\rho^h}\left[\frac{N^l}{\left(c_D^l\right)^k} - \rho^l\frac{N^h}{\left(c_D^h\right)^k}\right] \\ &= \frac{2\,(c_M)^k\,(k+1)\,\gamma}{\eta\,(1-\rho^l\rho^h)}\left[\frac{\alpha - c_D^l}{\left(c_D^l\right)^{k+1}} - \rho^l\frac{\alpha - c_D^h}{\left(c_D^h\right)^{k+1}}\right]. \end{aligned} \tag{26}$$

In the appendix, we show that (26) further implies that $c_X^l < c_D^l$ in this non-specialized equilibrium ($N_E^l > 0$), so that only a subset of relatively more productive firms export. The remaining higher cost firms (with cost between c_X^l and c_D^l) only serve their domestic market. $G(c_D^l)N_E^l$ thus also represents the total number of firms producing in l (no firm produces in l without also serving its domestic market).

[14] The previously derived condition for the demand parameters α and η, and k again ensure that $q_0^l > 0$ as has been assumed.

3.4 Reciprocal Dumping and Arbitrage Opportunities

Brander and Krugman (1983) have shown that reciprocal dumping must occur in intra-industry trade equilibria under Cournot competition where representative firms produce a single homogeneous good in two countries. Ottaviano, Tabuchi and Thisse (2002) show that dumping can also occur with differentiated products under monopolistic competition with representative firms. We extend this result to our current framework, where firms with heterogeneous costs produce differentiated varieties and face different residual demand price elasticities.[15] Given the optimal price functions $p_D^l(c) = \left(c_D^l + c\right)/2$ and $p_X^l(c) = \tau^h(c_X^l + c)/2$ from (20), $c_X^l < c_D^l$ implies that $p_X^l(c)/\tau^h < p_D^l(c), \forall c \geq c_X^l$. Therefore, all exporters set F.O.B. export prices (net of incurred trade costs) strictly below their prices in the domestic market. Thus, as emphasized by Weinstein (1992), dumping does not imply predatory pricing. Furthermore, as shown by Ottaviano, Tabuchi and Thisse (2002), dumping need not be the outcome of oligopoly and strategic interactions between firms, which are absent in our model.

As described by Feenstra et al (2001), dumping behavior is closely linked to arbitrage conditions for the re-sale of goods across markets. This same link holds in our model, where dumping by exporters from country l ($p_X^l(c)/\tau^h < p_D^l(c)$) is equivalent to a no-arbitrage condition precluding the profitable export resale by a third party of a good produced and sold in country l. The dumping condition also precludes profitable resale of a good exported to country l, back in its origin country h ($p_D^h(c)/\tau^h < p_X^h(c)$).[16]

3.5 The Impact of Trade

We previously described how the distribution of the exporters' delivered cost $\tau^l c$ to country l matched the distribution of the domestic firms' cost c in country l. We then argued that this would lead to matching price distributions for both domestic firms in a country, and exporters to that country. This argument extends to the distribution of all the other firm-level variables (markups, output, revenue, and profit). Thus, the distribution of all these firm performance measures in the open economy equilibrium are identical to those in a closed economy case with a matching cost cutoff c_D. When analyzing the impact of trade, we can therefore focus on the determination of the cost cutoff governed by (23).

[15] In related work, Holmes and Stevens (2004) show that the assumption of lower markups in non-local markets, along with differences in transport costs across sectors, can explain cross-market differences in the size distribution of firms.

[16] Since $p_X^h(c) = p_D^l(c\tau^l) > p_X^l(c\tau^l)/\tau^h = p_D^h(c\tau^l\tau^h)/\tau^h > p_D^h(c)/\tau^h$.

Comparing this new cutoff condition to the one derived for the closed economy (15) immediately reveals that the cost cutoff is lower in the open economy: trade increases aggregate productivity by forcing the least productive firms to exit. This effect is similar to that analyzed in Melitz (2003) but works through a different economic channel. In Melitz (2003), trade induces increased competition for scarce labor resources as real wages are bid up by the relatively more productive firms who expand production to serve the export markets. The increase in real wages forces the least productive firms to exit. In that model, import competition does not play a role in the reallocation process due to the C.E.S. specification for demand (residual demand price elasticities are exogenously fixed and unaffected by import competition). In the current model, the impact of these two channels – via increased factor market or product market competition – is reversed: increased product market competition is the only operative channel. Increased factor market competition plays no role in the current model, as the supply of labor to the differentiated goods sector is perfectly elastic. On the other hand, import competition increases competition in the domestic product market, shifting up residual demand price elasticities for all firms at any given demand level. This forces the least productive firms to exit. This effect is very similar to an increase in market size in the closed economy: the increased competition induces a downward shift in the distribution of markups across firms. Although only relatively more productive firms survive (with higher markups than the less productive firms who exit), the average markup is reduced. The distribution of prices shifts down due to the combined effect of selection and lower markups. Again, as in the case of larger market size in a closed economy, average firm size and profits increase – as does product variety.[17] In this model, welfare gains from trade thus come from a combination of productivity gains (via selection), lower markups (pro-competitive effect), and increased product variety.

3.6 Market Size Effects

We now focus on the consequences of market size differences for cross-country characteristics in the open economy equilibrium. Once again, these cross-country differences in firm performance measures will be determined by the differences in the cost cutoffs c_D^l, as shown in (23). This immediately highlights how costly trade does not completely integrate markets as respective country size plays an important role in determining all firm performance measures and welfare in each country: When trade costs are symmetric ($\rho^l = \rho^h$), the larger country will have a lower cutoff,

[17] Comparisons of changes in the variance of all performance measures are also identical to the case of increased market size.

and thus higher average productivity and product variety, along with lower markups and prices (relative to the smaller country). Welfare levels are thus higher in the larger country. Moreover, the latter will attract relatively more entrants and local producers. In short, all of the size-induced differences across countries in autarky persist (although not to the same extent). It is in this sense that costly trade does not completely integrate markets.

Surprisingly, (23) also indicates that the size of a country's trading partner does not affect the cost cutoff (and hence all firm performance measures and welfare). This highlights some important offsetting effects of trading partner size – although the exact outcome of these trade-offs are naturally influenced by our functional form assumptions. On the export side, a larger trading partner represents increased export market opportunities. However, this increased export market size is offset by its increased 'competitiveness' (a greater number of more productive firms are competing in that market, driving down markups). On the import side, a larger trading partner represents an increased level of import competition. In the long run, this is offset by a smaller proportion of entrants, and hence less competition in the smaller market.[18]

3.7 The Open Economy in the Short-Run

We now introduce the parallel version of the economy in the short-run when it is open to trade. We will use this to separately identify the short and long run effects of liberalization in the following section. As was the case for the closed economy, no entry and exit is possible in the short run; incumbent firms decide whether to produce or shut-down. Each country l is thus characterized by a fixed number of incumbents $\bar{N}_D^l$ with cost distribution $\bar{G}^l(c)$ on $[0, \bar{c}_M^l]$. We continue to assume that productivity $1/c$ is distributed Pareto with shape k, implying $\bar{G}^l(c) = \left(c/\bar{c}_M^l\right)^k$. A firm produces if it can earn non-negative profits from sales to either its domestic or export market. This leads to cost cutoff conditions for sales in either market: $c_D^l = \sup\left\{c : \pi_D^l(c) \geq 0 \text{ and } c \leq \bar{c}_M^l\right\}$ and $c_X^l = \sup\left\{c : \pi_X^l(c) \geq 0 \text{ and } c \leq \bar{c}_M^l\right\}$.[19] Either of these cutoffs can reach their upper bound at $\bar{c}_M^l$, in which case all incumbent firms produce. So long as this is not the case, the cutoffs must

[18] As highlighted by (26), differences in country size induce a larger proportion of entrants into the larger market. (26) also indicates that country size differences must be bounded to maintain an equilibrium with incomplete specialization in the differentiated good sector. As country size differences become arbitrarily large, the number of entrants in the smaller country is driven to zero.

[19] In the short-run, it is possible for $c_X^l > c_D^l$, in which case firms with cost c in between these two cutoffs produce and export, but do not sell on their domestic market.

satisfy the threshold price conditions in (24):

$$\begin{aligned} N^l &= \frac{2\,(k+1)\,\gamma}{\eta}\frac{\alpha - c_D^l}{c_D^l}, \qquad \text{whenever } c_D^l < \bar{c}_M^l, \\ N^h &= \frac{2\,(k+1)\,\gamma}{\eta}\frac{\alpha - \tau^h c_X^l}{\tau^h c_X^l}, \qquad \text{whenever } c_X^l < \bar{c}_M^l, \end{aligned} \tag{27}$$

where N^l represents the endogenous number of sellers in country l in the short-run. Note that $c_X^h = c_D^l/\tau^l$ as in the long-run whenever both cutoffs are below their respective upper bounds $\bar{c}_M^h$ and $\bar{c}_M^l$.

There are $\bar{N}_D^l \bar{G}^l(c_D^l)$ producers from country l who sell in their domestic market, and $\bar{N}_D^h \bar{G}^h(c_X^h)$ exporters from h to l. These numbers must add up to the total number of sellers in country l: $N^l = \bar{N}_D^l \bar{G}^l(c_D^l) + \bar{N}_D^h \bar{G}^h(c_X^h)$. Combining this with the threshold price conditions yield expressions for the cost cutoffs in both countries:

$$\frac{\alpha - c_D^l}{\left(c_D^l\right)^{k+1}} = \frac{\eta}{2(k+1)\gamma}\left[\frac{\bar{N}_D^l}{\left(\bar{c}_M^l\right)^k} + \rho^l \frac{\bar{N}_D^h}{\left(\bar{c}_M^h\right)^k}\right], \quad \text{whenever } c_D^l < \bar{c}_M^l \text{ and } c_X^l < \bar{c}_M^l. \tag{28}$$

This condition clearly highlights the important role played by trading partner industrial size and import competition in the short run. An increase in the number of incumbents in country h increases import competition in country l and generates a decreases in the cost cutoff c_D^l, forcing some of the less productive firms in country l to shut down.[20] This effect is only offset with entry in the long run.

4 Trade Liberalization

We have just shown how the firm location decision (driven by free entry in the long run) plays an important role in determining the extent of competition across markets in the open economy. This location decision also crucially affects the long run consequences of trade liberalization – especially in situations where the decreases in trade barriers are asymmetric.

4.1 Bilateral Liberalization

Before illustrating the consequences of asymmetric liberalization, we first quickly describe the case of symmetric liberalization. Here, we assume that trade costs are symmetric, $\tau^H = \tau^F = \tau$, and

[20] The overall number of sellers in country l (and hence product variety) increases as the increase in exporters from h dominates the decrease in domestic producers in l.

analyze the effects of decreases in τ (increases in $\rho^H = \rho^F = \rho$). In this case, the equilibrium cutoff condition (23) can be written:

$$c_D^l = \left[\frac{\gamma\phi}{L^l\,(1+\rho)}\right]^{\frac{1}{k+2}}. \tag{29}$$

Bilateral liberalization thus increases competition in both markets, leading to proportional changes in the cutoffs (and hence proportional increases in aggregate productivity) in both countries.[21] The effects of such liberalization are thus qualitatively identical to those described for the transition from autarky to the open economy: Product variety increases as a result of the increased competition, which also induces a decrease in markups and prices. Again, welfare rises from a combination of higher productivity, lower markups, and increased product variety.

Symmetric trade liberalization induces all of the same qualitative results in the short run. Although these effects do not depend on relative country size (so long as the differentiated good is produced in both countries), differences in country size nevertheless induce important changes in the relative pattern of entry in the long run following liberalization. Assuming $L^l > L^h$, the positive entry differential $N_E^l - N_E^h$ widens with liberalization as entry in the bigger market becomes relatively more attractive. This also induces a growing differential in the number of domestic producers $N_D^l - N_D^h$ (see appendix for proofs).

4.2 Unilateral Liberalization

We now describe the effects of a unilateral liberalization by country l (an increase in ρ^l, holding ρ^h constant). Given the cutoff condition (23), this leads to an increase in the cost cutoff c_D^l (less competition in the liberalizing country) – whereas the cutoff c_D^h in the country's trading partner decreases, indicating an increase in competition there. The liberalizing country thus experiences a welfare loss while its trading partner experiences a welfare gain.[22] As previously mentioned, these results are driven by the change in firm location induced by entry in the long run. (26) indicates that the number of entrants N_E^l in the liberalizing country decreases, while the number of entrants in the other country, N_E^h, increases.

In order to isolate the direct impact of liberalization from the long run effects generated by entry, we now turn to the short run responses to unilateral liberalization by country l. The equilibrium condition (28) for the short run cutoffs clearly shows that the cost cutoff c_D^l decreases in

[21] As indicated by (26), the number of entrants in the smaller economy is driven to zero when trade costs drop below a threshold level – and the smaller economy no longer produces the differentiated good. We assume that trade costs remain above this threshold level.

[22] Once again, the response of the cutoffs determines the response in all the other country level variables.

response to this liberalization – while the cost cutoff in h, c_D^h, remains unchanged. This highlights the pro-competitive effects of unilateral liberalization in the short-run. Although the increase in import competition in l forces some of the least productive firms there to exit, product variety N^l nevertheless increases as the increased number of exporters to l dominates the decrease in domestic producers N_D^l (see (27)). Welfare in the liberalizing country (in the short run) therefore rises from a combination of higher productivity, lower markups, and increased product variety (welfare in the trading partner remains unchanged in the short run). These results clearly underline how the welfare loss associated with unilateral liberalization is driven by the shift in the pattern of entry (favoring the non-liberalizing trading partner) in the long run.

These long run effects of liberalization on firm 'de-location' have been extensively studied in previous work (see, e.g. Horstmann and Markusen, 1986, Venables, 1985, Venables, 1987; and the synthesis in Helpman and Krugman, 1989 ch. 7 and Baldwin et al, 2003 ch. 12). The novel features in our work show how this type of liberalization also affects firm selection, aggregate productivity, product variety, and markups within a single model.[23]

4.3 Preferential Liberalization

So far, our analysis has been restricted to two countries. This has generated a rich set of insights on the combined impact of market size and trade liberalization on industry performance and welfare. However, focusing on two countries in isolation neglects the effects of a country's position within an international trading network (which is determined by the whole matrix of bilateral trade barriers). When all trade barriers are symmetric, the insights of a multi-country model are a straightforward extension of the two-country case. However, new insights arise when bilateral barriers are allowed to differ.

While our model can easily deal with any number of countries of any size along with an arbitrary matrix of trade costs (see appendix), considering three countries of equal size is enough to recover some of these related insights. We therefore introduce a third trading partner T, with $L^T = L^H = L^F = L$. Countries differ in terms of trade barriers that are assumed to be pair-wise symmetric, with $\rho^{lh} = \left(\tau^{lh}\right)^{-k} = \left(\tau^{hl}\right)^{-k}$ measuring the 'freeness' of trade between countries $l = \{H, F, T\}$ and $h \neq l$. Similarly, ρ^{lt} and ρ^{ht} measure the 'freeness' of trade between l and h, and the third country $t \neq l \neq h$. As with the case of unilateral liberalization, preferential trade liberalization

[23] Since most of the previous literature assumes representative firms, the link between trade policy and aggregate productivity (via firm selection into the domestic market) and product variety (via firm selection into export markets) is absent.

(non-proportional changes in these three bilateral trade barriers) induces important shifts in the pattern of entry across countries in the long-run. Once again, we analyze both the long run and short run effects of such liberalization.

Long run equilibrium

With three countries of equal size, the free entry condition (22) in country l becomes:

$$\left(c_D^l\right)^{k+2} + \rho^{lh}\left(c_D^h\right)^{k+2} + \rho^{ht}\left(c_D^t\right)^{k+2} = \frac{\gamma\phi}{L} \qquad l = \{H, F, T\}, t \neq l \neq h.$$

This provides a system of three linear equations in the three domestic cutoffs. When pair-wise trade barriers are symmetric, the long run cutoffs are given by:

$$c_D^l = \left[\frac{\gamma\phi}{L}\frac{\left(1-\rho^{ht}\right)\left[1+\rho^{ht}-\left(\rho^{lh}+\rho^{lt}\right)\right]}{1+2\rho^{lh}\rho^{lt}\rho^{ht}-\left(\rho^{lh}\right)^2-\left(\rho^{lt}\right)^2-\left(\rho^{ht}\right)^2}\right]^{\frac{1}{k+2}}. \tag{30}$$

The corresponding number of sellers N^l in country l is still given by (24), while the number of entrants solve $N_E^l + \rho^{lh}N_E^h + \rho^{lt}N_E^t = N^l\left(c_M/c_D^l\right)^k$.

In (30), international differences in cutoffs stem from the relative freeness measure $\left(1-\rho^{ht}\right)\left[1+\rho^{ht}-\left(\rho^{lh}+\rho^{lt}\right)\right]$, which implies that the cutoff is lowest in a country l with the lowest sum of bilateral barriers (highest $\rho^{lh}+\rho^{lt}$). In effect, this country is the best export base or 'hub'. Moreover, since ρ^{ht} enters the expression of the cutoff for country l, any change in bilateral trade costs affects all three countries. This has important implications for preferential trade agreements.[24] To see this as clearly as possible, consider three countries with initially symmetric trade barriers ($\rho^{lt} = \rho$). The initial cutoffs are then identical and equal to (see (30))

$$c_D = \left[\frac{\gamma\phi}{L}\frac{1}{1+2\rho}\right]^{\frac{1}{k+2}}. \tag{31}$$

A preferential trade agreement is then introduced between H and F, inducing $\rho^{HF} = \rho' > \rho = \rho^{FT} = \rho^{HT}$. The new trade regime affects the cutoffs for all countries. From (30), the cutoffs in the liberalizing countries are then

$$c_D^H = c_D^F = \left[\frac{\gamma\phi}{L}\frac{1-\rho}{1-2\rho^2+\rho'}\right]^{\frac{1}{k+2}}, \tag{32}$$

[24] In the appendix, we show how such 'third-country effect' can also be integrated in a gravity equation.

while the cutoff in the third country is given by

$$c_D^T = \left[\frac{\gamma\phi}{L} \frac{(1-\rho) + (\rho' - \rho)}{1 - 2\rho^2 + \rho'} \right]^{\frac{1}{k+2}}. \tag{33}$$

The number of entrants in all three countries are given by (recall that $c_D^H = c_D^F$)

$$\begin{aligned} N_E^H &= N_E^F = \frac{2\,(c_M)^k\,(k+1)\,\gamma}{\eta\,(1-2\rho^2+\rho')} \left[\frac{\alpha - c_D^H}{\left(c_D^H\right)^{k+1}} - \rho \frac{\alpha - c_D^T}{\left(c_D^T\right)^{k+1}} \right], \\ N_E^T &= \frac{2\,(c_M)^k\,(k+1)\,\gamma}{\eta\,(1-2\rho^2+\rho')} \left[\left(1+\rho'\right) \frac{\alpha - c_D^T}{\left(c_D^T\right)^{k+1}} - 2\rho \frac{\alpha - c_D^H}{\left(c_D^H\right)^{k+1}} \right]. \end{aligned}$$

Comparing (31)-(33), it is easily verified that preferential liberalization leads to lower cutoffs in the liberalizing countries and a higher cutoff in the third country. Thus, average costs, prices, and markups also decrease in the liberalizing countries while they rise in the third country. The liberalizing countries become better 'export bases': they gain better access to each other's market while maintaining the same ease of access to the third country's market. Thus, preferential liberalization leads to long run welfare gains for the liberalizing countries, along with a welfare loss for the excluded country.

Short run

In order to highlight how the welfare loss in the third country is driven by the long run shift in the pattern of entry, we briefly characterize the short run response to the liberalization agreement between H and F. The short run equilibrium in country l solves:

$$\frac{\alpha - c_D^l}{\left(c_D^l\right)^{k+1}} = \frac{\eta}{2(k+1)\gamma} \left[\frac{\overline{N}_D^l}{\left(\bar{c}_M^l\right)^k} + \rho^{lh} \frac{\overline{N}_D^h}{\left(\bar{c}_M^h\right)^k} + \rho^{lt} \frac{\overline{N}_D^t}{\left(\bar{c}_M^t\right)^k} \right],$$

where the number of incumbents $\bar{N}_D^l$ and their productivity distribution on $[0, \bar{c}_M^l]$ are fixed in all countries, as in the previous short run examples. When these numbers and distributions are symmetric (same $\bar{N}$ and $\bar{c}_M$), the country with the best accessibility (highest $\rho^{hl} + \rho^{lt}$) will have the lowest cutoff c_D^l. This country will have the lowest number of operating firms $N_D^l = \bar{N}_D^l G(c_D^l)$, but the highest number of sellers N^l (see (27)). Since the preferential liberalization between H and F does not affect accessibility to the third country ($\rho = \rho^{FT} = \rho^{HT}$), the cutoff in the latter is unaffected by the preferential liberalization in the short run. As in the case of unilateral

liberalization, it is the long run change in entry behavior that is responsible for reduced competition and lower welfare in the excluded third country. On the other hand, the liberalizing countries gain in both the short run (via the direct pro-competitive effect) and the long run, when the pro-competitive effect is reinforced by the beneficial impact of increased entry.

5 Conclusion

We have presented a rich, though tractable, model that predicts how a wide set of industry performance measures (productivity, size, price, markup) respond to changes in the world trading environment. Our model incorporates heterogeneous firms and endogenous markups that respond to the toughness of competition in a market. In such a setting, we show how market size induces important changes in industry performance measures: larger markets exhibit tougher competition resulting in lower average markups and higher aggregate productivity. We also show how costly trade does not completely integrate markets and thus does not obviate these important consequences of market size differences across trading partners.

We then analyze several different trade liberalization scenarios. Our model highlights the pro-competitive effects of increased import competition and its effect on markups, productivity, and product variety in the liberalized import market. Our model also echoes the findings in previous work that show how the short run gains of asymmetric liberalization can be reversed by shifts in the pattern of entry in the long run. However, our model additionally incorporates the important feedbacks between entry and firm selection into domestic and export markets.

Although each of these individual channels for trade-induced gains have been previously analyzed in models with different structures, we believe it is important to show how all of these channels can be captured within a single unified framework. This framework develops a new and very tractable way of describing how differences in market size and trade costs across trading partners affect the distribution of key firm-level performance measures across markets. We hope that this provides a useful foundation for future empirical investigations.

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Appendix

A Variance of Firm Performance Measures

Let $\sigma_c^2 = \left[\int_0^{c_D} (c-\bar{c})^2 \, dG(c)\right] / G(c_D)$ denote the variance of the firm cost draws. As was mentioned earlier in the main text, the variance of all the firm performance measures can be written as simple expressions of this variance:

$$\sigma_p^2 = \tfrac{1}{4}\sigma_c^2, \quad \sigma_q^2 = \tfrac{L^2}{4\gamma^2}\sigma_c^2,$$
$$\sigma_\mu^2 = \tfrac{1}{4}\sigma_c^2, \quad \sigma_r^2 = \tfrac{L^2}{16\gamma^2}\sigma_{c^2}^2,$$

where $\sigma_z^2 = \left[\int_0^{c_D} [z(c)-\bar{z}]^2 \, dG(c)\right] / G(c_D)$ and $\bar{z}$ denote the variance and mean of a firm performance measure $z(c)$. Given the chosen parametrization for the cost draws, $\sigma_c^2 = \left[k/(k+1)^2(k+2)\right] c_D^2$.

B Multiple Countries, Asymmetric Trade Costs, and Comparative Advantage

Our model can be readily extended to a setting with an arbitrary number of countries, asymmetric trade costs, and comparative advantage. Let M denote the number of countries, indexed by $l = 1, ..., M$. As in the main text $\rho^{lh} = \left(\tau^{lh}\right)^{-k} \in (0,1]$ measures the 'freeness' of trade for exports from l to h. When trade costs are interpreted in a wide sense as all distance-related barriers, then within country trade may not be costless, and we allow for any $\rho^{ll} \in (0,1]$. We introduce comparative advantage as technology differences that affect the distribution of the firm-level productivity draws. For tractability, we assume that firm productivity $1/c$ is distributed Pareto with shape k in all countries, but allow for differences in the support of the distributions via differences in the upper-bound cost c_M^l. The cost draws in country l thus have a distribution $G^l(c) = \left(c/c_M^l\right)^k$. Whenever $c_M^l < c_M^h$, country l will have a comparative advantage with respect to country h in the differentiated good sector: entrants in country l have a better chance of getting higher productivity draws.[25]

In this extended model, the free entry condition (22) in country l becomes:

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

where $\psi^l = \left(c_M^l\right)^{-k}$ is an index of comparative advantage. This yields a system of M equations

[25] The distribution of productivity draws in l stochastically dominates that in h.

that can be solved for the M equilibrium domestic cutoffs using Cramer's rule:

$$c_D^l = \left(\frac{2(k+1)(k+2) f_E \gamma}{|P|} \frac{\sum_{h=1}^{M} |C_{hl}| / \psi^h}{L^l} \right)^{\frac{1}{k+2}}, \tag{B.1}$$

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 three sources: own country size (L^l), as well as a combination of market access and comparative advantage ($\sum_{h=1}^{M} |C_{hl}| / \psi^h$). Countries benefiting from a larger local market, a better distribution of productivity draws, and better market accessibility have lower cutoffs.

The mass of sellers N^l 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^l in all countries, there are $G^l(c_D^l)N_E^l$ domestic producers and $\sum_{h \neq l} G^l(c_X^{hl})N_E^h$ exporters selling in l, where c_X^{hl} is the export cutoff from h to l. This implies:

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

The latter provides a system of M linear equations that can be solved for the number of entrants in the M countries using Cramer's rule:[26]

$$N_E^l = \frac{2\,(k+1)\,\gamma}{\eta\,|P|\,\psi^l} \sum_{h=1}^{M} \frac{\left(\alpha - c_D^h\right)|C_{lh}|}{\left(c_D^h\right)^{k+1}} \tag{B.2}$$

Given N_E^l entrants in country l, $N_E^l G^l(c_D^l)$ firms survive and produce for the local market. Among the latter, $N_E^l G^l(c_X^l)$ export to country h.

C A Gravity Equation

Our multilateral model with heterogeneous firms, asymmetric trade costs, and comparative advantage also yields a gravity equation for aggregate bilateral trade flows. An exporter with cost c from

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

country h generates export sales $r_X^{lh}(c) = p_X^{lh}(c) q_X^{lh}(c)$ where (see (19) and (20))

$$\begin{aligned} p_X^{lh}(c) &= \frac{\tau^{lh}}{2}\left(c_X^{lh} + c\right) = \frac{1}{2}\left(c_D^h + \tau^{lh} c\right), \\ q_X^{lh}(c) &= \frac{L^h \tau^{lh}}{2\gamma}\left(c_X^{lh} - c\right) = \frac{L^h}{2\gamma}\left(c_D^h - \tau^{lh} c\right). \end{aligned}$$

Aggregating these export sales $r_X^{lh}(c)$ over all exporters from l to h (with cost $c \leq c_X^{lh}$) yields the aggregate bilateral exports from l to h:[27]

$$\begin{aligned} EXP^{lh} &= N_E^l \int_0^{c_X^{lh}} r_X^{lh}(c) dG^l(c) \\ &= N_E^l \frac{L^h}{4\gamma} \int_0^{c_D^h/\tau^{lh}} \left[\left(c_D^h\right)^2 - \left(\tau^{lh} c\right)^2\right] dG^l(c) \\ &= \frac{1}{2\gamma(k+2)} N_E^l \psi^l L^h \left(c_D^h\right)^{k+2} \left(\tau^{lh}\right)^{-k}. \end{aligned} \tag{C.1}$$

This gravity equation determines bilateral exports as a log-linear function of bilateral trade barriers and country characteristics. As in Eaton and Kortum (2002) and Helpman, Melitz, and Rubinstein (2007), (C.1) reflects the joint effects of country size, technology (comparative advantage), and geography on both the extensive (number of traded goods) and intensive (amount traded per good) margins of trade flows. Similarly, (C.1) highlights how – holding the importing country size fixed – tougher competition in that country (lower average prices, reflected by a lower c_D^l) dampens exports by making it harder for potential exporters to break into that market.

D Selection Into Export Markets

In this section, we show that the assumption of a non-specialized equilibrium where both countries produce the differentiated good ($N_E^l > 0, \quad l = H, F$) implies that only a subset of relatively more productive firms choose to export in either country ($c_X^l < c_D^l, \quad l = H, F$). In the text, we showed

[27] The integration measure $G^l(c_X^{lh})$ represents the proportion of entrants N_E^l in l that export to h.

that the number of entrants N_E^l satisfied (26). Thus,

$$\begin{aligned} N_E^l > 0 \quad &\Longleftrightarrow \quad \frac{\alpha - c_D^l}{\left(c_D^l\right)^{k+1}} > \rho^l \frac{\alpha - c_D^h}{\left(c_D^h\right)^{k+1}} \\ &\Longleftrightarrow \quad \frac{\alpha - c_D^l}{\alpha - c_D^h} \left(\frac{c_D^h}{c_D^l}\right)^{k+1} > \rho^l \\ &\Longleftrightarrow \quad \frac{\frac{\alpha}{\tau^l} - c_X^h}{\alpha - c_D^h} \left(\frac{c_D^h}{c_X^h}\right)^{k+1} > 1, \end{aligned}$$

which is incompatible with $c_X^h \geq c_D^h$. Therefore, $c_X^h < c_D^h$ for $h = H, F$.

E Bilateral Liberalization

In this section, we prove a set of results for the two country model with different country sizes and symmetric trade barriers. Some results are already mentioned in the main text, while others complement the latter and provide a more detailed characterization of the effects of bilateral liberalization.

When trade barriers are symmetric, $\rho^l = \rho^h = \rho$, the number of entrants from (26) can be simplified to:

$$N_E^l = \frac{(c_M)^k}{1-\rho^2} \left[\frac{N^l}{\left(c_D^l\right)^k} - \rho \frac{N^h}{\left(c_D^h\right)^k} \right]. \tag{E.1}$$

Among these entrants, only

$$N_D^l = G(c_D^l) N_E^l = \left(\frac{c_D^l}{c_M}\right)^k N_E^l \tag{E.2}$$

firms survive and produce. Without loss of generality, we assume $L^l > L^h$. The following results then apply:

1. The domestic cutoff is lower in the larger country: $c_D^l < c_D^h$. *Proof*: Follows directly from (29).

2. There are more sellers in the larger country: $N^l > N^h$. *Proof*: Given 1, follows directly from (24).

3. There are more entrants in the larger country: $N_E^l > N_E^h$. *Proof*: Given 1 and 2, follows directly from (E.1).

4. There are more local producers in the larger country: $N_D^l > N_D^h$. *Proof*: Given (E.1) and (E.2),

$$N_D^l = \frac{1}{1-\rho^2}\left[N^l - \rho N^h \left(\frac{c_D^l}{c_D^h}\right)^k\right]. \tag{E.3}$$

The result then follows directly from 1 and 2.

5. Trade liberalization reduces the domestic cutoff differential: $d\left(c_D^h - c_D^l\right)/d\rho < 0$. *Proof*: Given (29), the result follows directly from

$$c_D^h - c_D^l = \left[\frac{\gamma\phi}{1+\rho}\left(\frac{1}{L^h} - \frac{1}{L^l}\right)\right]^{\frac{1}{k+2}} > 0.$$

6. Trade liberalization increases the cross-country difference in the number of sellers: $d\left(N^l - N^h\right)/d\rho > 0$. *Proof*: Given (29) and (27), the result follows directly from

$$\begin{aligned} N^l - N^h &= \frac{2(k+1)\gamma\alpha}{\eta}\left(\frac{1}{c_D^l} - \frac{1}{c_D^h}\right) \\ &= \frac{2(k+1)\gamma\alpha}{\eta}\left(\frac{1+\rho}{\gamma\phi}\right)^{\frac{1}{k+2}}\left[\left(L^l\right)^{\frac{1}{k+2}} - \left(L^h\right)^{\frac{1}{k+2}}\right] > 0. \end{aligned}$$

7. Trade liberalization increases the cross-country difference in the number of entrants: $d\left(N_E^l - N_E^h\right)/d\rho > 0$. *Proof*: Given (29), (24), and (E.1),

$$\begin{aligned} N_E^l - N_E^h &= \frac{(c_M)^k}{1-\rho}\left[\frac{N^l}{\left(c_D^l\right)^k} - \frac{N^h}{\left(c_D^h\right)^k}\right] \\ &= \frac{2(k+1)\gamma}{\eta}\frac{(c_M)^k}{1-\rho}\left[\frac{\alpha - c_D^l}{\left(c_D^l\right)^{k+1}} - \frac{\alpha - c_D^h}{\left(c_D^h\right)^{k+1}}\right] > 0. \end{aligned}$$

Then,

$$\begin{aligned} \frac{d\left(N_E^l - N_E^h\right)}{d\rho} &= \frac{2(k+1)\gamma(c_M)^k}{\eta}\frac{1}{(1-\rho)^2}\left[\frac{\alpha - c_D^l}{\left(c_D^l\right)^{k+1}} - \frac{\alpha - c_D^h}{\left(c_D^h\right)^{k+1}}\right] \\ &\quad + \frac{2(k+1)\gamma(c_M)^k}{\eta(k+2)}\frac{1}{(1+\rho)(1-\rho)}\left[\frac{\alpha(k+1) - k\,c_D^l}{\left(c_D^l\right)^{k+1}} - \frac{\alpha(k+1) - k\,c_D^h}{\left(c_D^h\right)^{k+1}}\right] \\ &> 0 \end{aligned}$$

8. Trade liberalization increases the cross-country difference in the number of producers:

$d\left(N_D^l - N_D^h\right)/d\rho > 0$. *Proof*: Given (29) and (E.3),

$$\begin{aligned} N_D^l - N_D^h &= \frac{1}{1-\rho^2}\left\{N^l\left[1+\rho\left(\frac{c_D^h}{c_D^l}\right)^k\right] - N^h\left[1+\rho\left(\frac{c_D^l}{c_D^h}\right)^k\right]\right\} \\ &= \frac{1}{1-\rho^2}\left\{N^l\left[1+\rho\left(\frac{L^l}{L^h}\right)^{\frac{k}{k+2}}\right] - N^h\left[1+\rho\left(\frac{L^h}{L^l}\right)^{\frac{k}{k+2}}\right]\right\}. \end{aligned}$$

Furthermore,

$$\begin{aligned} \frac{dN^l}{d\rho} &= \frac{dN^l}{dc_D^l}\frac{dc_D^l}{d\rho} = \frac{2\,(k+1)\,\gamma\alpha}{\eta(k+2)}\frac{1}{c_D^l}\frac{1}{1+\rho}, \\ \frac{dN^h}{d\rho} &= \frac{dN^h}{dc_D^h}\frac{dc_D^h}{d\rho} = \frac{2\,(k+1)\,\gamma\alpha}{\eta(k+2)}\frac{1}{c_D^h}\frac{1}{1+\rho} < \frac{dN^l}{d\rho}. \end{aligned}$$

Given $\left(L^l/L^h\right)^{k/(k+2)} > \left(L^h/L^l\right)^{k/(k+2)}$, then $d\left(N_D^l - N_D^h\right)/d\rho > 0$.