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COUNTRY SIZE, PRODUCTIVITY AND TRADE SHARE CONVERGENCE: AN ANALYSIS OF HETEROGENOUS FIRMS AND COUNTRY SIZE DEPENDENT BEACHHEAD COSTS

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ABSTRACT

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JEL Classification: D21, F12 and F15
Keywords: beachhead costs, heterogenous firms and market size

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Country Size, Productivity and Trade Share Convergence: An analysis of heterogenous firms and country size dependent beachhead costs*

Anders Akerman[†] and **Rikard Forslid**[‡]

October 2007

Abstract

This paper modifies the heterogenous firms and trade model by Melitz (2003) by explicitly modelling the entry cost of a firm in a new market as a function of market size. This leads to several new predictions compared to the standard model: The productivity of non exporters and exporters depends on market size. Moreover, manufacturing export shares vary inversely with country size. However, export shares converge (upwards) as markets are integrated. The empirical part of the paper offers support for our model specification.

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1 Introduction

It is empirically well established that there are systematic productivity differences among firms; see Tybout (2003) for a survey.[1] In particular, exporting firms tend to be more productive, larger, and live longer than domestic firms. There is also evidence that multinational firms tend to be more productive than exporters (Helpman et al. (2004)).

These empirical results have spurred the development of a new theoretical literature on trade with heterogenous firms. The explanation for the empirical finding that exporters are more productive than non-exporters is either iceberg trade costs associated with exports, as in

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[1] Other studies include Aw et al. (2000), Bernard och Jensen (1995, 1999a, 1999b, 2001), Clerides et al. (1998) as well as Eaton et al. (2004).

Bernard et al. (2003), or higher fixed costs associated with market entry into a foreign market, as in Melitz (2003) and Yeaple (2004). Only the most productive firms will find it profitable to pay the additional cost necessary for exports, and export firms will therefore, on average, be more productive.

In is, of course, also the case that firm productivity may vary because of country specific factors. Bernard et al. (2007) show how comparative advantage may strengthen the productivity gains associated with trade in a Melitz (2003) type model with heterogenous firms. We here investigate whether patterns of heterogeneity across firms and differences between non-exporters and exporters vary systematically with country size. That country or market size is of importance is indicated by Syverson (2004, 2006) who present empirical evidence of firms being more productive in larger (denser) markets. There are also stylized facts indicating that country size affects the relative performance of exporters to non-exporters. Schank et al. (2007) offer a literature overview where they measure the wage premium of exporter firms compared to non-exporter firms. Typically, a regression is run on firm level data with some measure of wages as the dependent variable, and with a dummy variable indicating whether the firm is an exporter or not. The estimated coefficient for this dummy variable is the exporter wage premium as compared to non-exporters. We interpret this wage premium to indicate productivity differences between exporters and non-exporters.[2] Figure 1 plots the exporter wage premium versus population size of countries in the studies surveyed in the appendix of Schank et al. (2007). We have also added an observation for Sweden using data provided by Statistics Sweden. Naturally, it must be acknowledged that all regressions are not done with exactly the same methodology or fully comparable data. Nevertheless, Figure 1 shows a negative correlation between export premium and population size. Running a regression on this data gives a slope of -0.605 with a t value of -3.68.

This paper suggests one channel through which country size can affect exporter productivity premium in a way consistent with Figure 1; namely, that country size affects the size of the beachhead cost that firms must pay when entering a new market (we will use the term beachhead cost for the market entry cost of the domestic as well as the foreign market). In particular, we assume that the beachhead cost in a market has a fixed and a market size dependent component. The fixed part may e.g. be related to standardization of the product for the market or to creating a marketing message for this particular market. The market size dependent component of the beachhead cost is interpreted as the marketing cost of introducing a new variety in a market. It is quite natural that this cost depends on the size of the market. For instance, the marketing cost of establishing a new product in a large market such as the U.S. is much higher than in a small market simply because of the higher cost of spreading the marketing message among more individuals. That the fixed entry cost depends on market size is also normally taken for

[2] This interpretation is consistent with e.g. learning effects as in Malchow-Møller et al. (2007) or by non-competitive wage setting a la Shapiro and Stiglitz (1984).

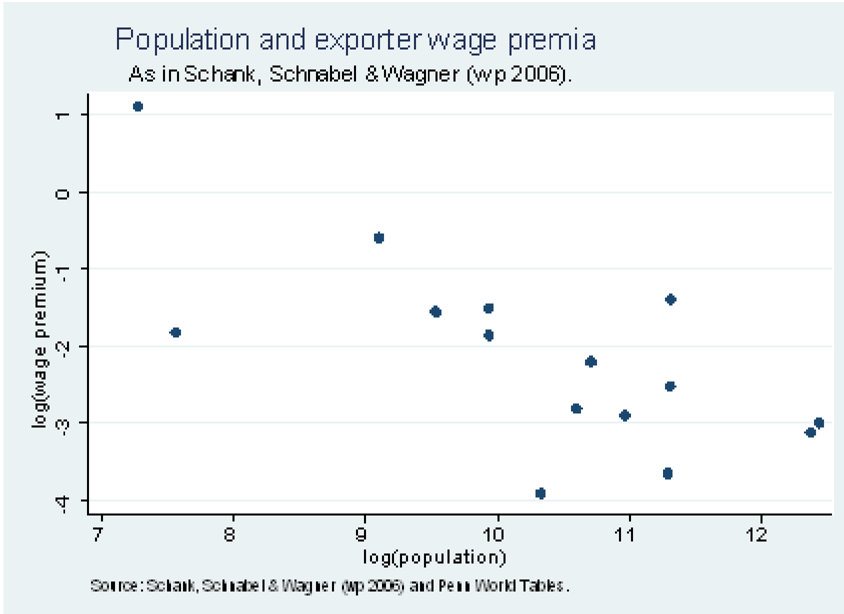

Figure 1: Export premiums decrease in country size.

granted in the marketing literature, where the marketing cost over sales ratio is a key variable[3].

We introduce the market size dependent beachhead cost into the Helpman et al. (2004) (HMY) version of the Melitz (2003) model. HMY analyse a model version with a freely traded homogenous good which fixes the factor price (wage). This allows for an analytical treatment of countries of asymmetric size. Since our focus is precisely on country size, we employ the HMY framework. Several new results emerge from our analysis. First, exporters as well as non-exporters in a large market are, on average, more productive than in a smaller market. Second, as in Melitz (2003), exporters are more productive than non-exporters. However, in line with the stylised evidence above, the productivity premium between exporters and non-exporters decreases with the home country size. Finally, we derive a set of new results related to trade volume. Contrary to what would be the case in the HMY framework, the manufacturing export share decreases in the size of the exporting country. Moreover it is shown that, as the fixed entry cost of exporters into each market decline, for instance as the result of economic integration, export shares converge.

The theoretical results are supported by the empirical section of the paper. Manufacturing export shares are affected by market size in accordance with our theoretical predictions, and we also find strong evidence of manufacturing export shares converging over time. Finally, we show how productivity is positively associated with market size in line with our theoretical model.

Our analysis is related to Melitz and Ottaviano (2005) who introduce firm heterogeneity *a la* Melitz (2003) in the model by Ottaviano et al. (2002) with a linear demand system and where the endogenous mark-ups of monopolistically competitive firms depend on market size. Melitz

[3] See e.g. Buzzell et al. (1975).

and Ottaviano (2005) find that firms selling to large markets are larger and more productive, since higher competition forces down the mark-ups in a large market. The same holds in our model, but the mechanism leading to higher productivity in a large market is instead that firms need to be more productive to afford the higher beachhead cost associated with a larger market. A difference as compared to Melitz and Ottaviano (2005) is that the productivity of firms in a market also depends on the size of other markets in our model. E.g. a larger foreign market implies more competition from imports, which forces up the productivity of domestic firms. One consequence of this dependence of the foreign market size is that export shares will vary with market size. The result that trade shares converge as the entry cost into foreign markets falls is naturally not present in Melitz and Ottaviano (2005), since they do not employ any beachhead costs.

Arkolakis (2006) presents a model of heterogenous firms, related to ours, where the marketing cost of each firm is convex in the share of consumers to be reached by the marketing message in a given market. The set-up implies scale economies in marketing so that the marginal firm to survive in a larger market is less productive than the corresponding firm in a smaller market. Average firm productivity is therefore lower in a larger market. Our model, on the contrary, implies that firms are more productive in large markets, since the variable component of the beachhead cost is higher in such a market. This feature is supported by the empirical part of our paper. Our results regarding the effect of falling fixed export entry costs on export shares have no correspondence in the model by Arkolakis (2006).

The paper is organized as follows: Section 2 contains the model and section 3 presents the theoretical results. Section 4 contains empirical tests of our theoretical predictions. Finally, section 5 concludes.

2 The Model

This paper employs a modified Helpman et al. (2004) version of Melitz' (2003) monopolistic competition trade model with heterogeneous firms.

2.1 Basics

There are two countries, home and foreign (denoted by '*'), and a single primary factor of production labour, L, used in the A-sector and the M-sector. The A-sector is a Walrasian, homogenous-goods sector with costless trade. The M-sector (manufactures) is characterized by increasing returns, Dixit-Stiglitz monopolistic competition and iceberg trade costs. M-sector firms face constant marginal production costs and three types of fixed costs. The first fixed cost, F_E, is the standard Dixit-Stiglitz cost of developing a new variety. The second and third fixed costs are 'beachhead' costs reflecting the one-time expense of introducing a new variety into a market. These costs are here assumed to depend on the size of the market.

There is heterogeneity with respect to firms' marginal costs. Each Dixit-Stiglitz firm/variety is associated with a particular labour input coefficient – denoted as a_j for firm j. After sinking F_E units of labour in the product innovation process, the firm is randomly assigned an 'a_j' from a probability distribution G(a).

Our analysis exclusively focuses on steady-state equilibria and intertemporal discounting is ignored; the present value of firms is kept finite by assuming firms to face a constant Poisson hazard rate δ of 'death'.

Consumers in each nation have two-tier utility functions with the upper tier (Cobb-Douglas) determining the consumer's division of expenditure among the sectors and the second tier (CES) dictating the consumer's preferences over the various differentiated varieties within the M-sector.

All individuals in country k have the utility function

$$U_k = C_M^{\mu} C_A^{1-\mu}, \tag{1}$$

where $k = H, F$, $\mu \in (0,1)$, and C_A is consumption of the homogenous good. Manufactures enter the utility function through the index C_M, defined by

$$C_M = \left[\int_0^n c_i^{(\sigma-1)/\sigma} di \right]^{\sigma/(\sigma-1)}, \tag{2}$$

n being the mass of varieties consumed, c_i the amount of variety i consumed and $\sigma > 1$ the elasticity of substitution.

Each consumer spends a share μ of his income on manufactures, and demand for a domestically produced variety i is therefore

$$x_i = \frac{p_i^{-\sigma}}{P^{1-\sigma}} \mu Y, \tag{3}$$

where p_i is the consumer price of variety i, Y **is** income, and $P \equiv \left(\int_0^n p_i^{1-\sigma} di \right)^{\frac{1}{1-\sigma}}$ the price index of manufacturing goods.

The unit factor requirement of the homogeneous good is one unit of labour. This good is freely traded, and since it is chosen as the numeraire

$$p_A = w = 1, \tag{4}$$

w being the nominal wage of workers in all countries.

Shipping the manufactured good involves a frictional trade cost of the "iceberg" form: for one unit of good from country j to arrive in country k, $\tau > 1$ units must be shipped. Trade costs are assumed to be equal in both directions. Profit maximization by manufacturing i firms leads to price

$$p_i = \frac{\sigma}{\sigma - 1} a_i, \qquad p_i = \frac{\sigma}{\sigma - 1} \tau a_i \tag{5}$$

in the domestic and foreign market, respectively.

Manufacturing firms draw their marginal cost, a, from the probability distribution $G(a)$ after having sunk F_E units of labour to develop a new variety.

Having learned their productivity, firms decide on entry in the domestic and foreign market. Firms will enter a market as long as the operating profit in this market is sufficiently large to cover the fixed beachhead cost associated with this market. Because of the constant mark-up pricing, it is easily shown that operating profits equal sales divided by σ. Using this and (3), the critical 'cut-off' levels of the marginal costs for the two countries are given by:

$$a_D^{1-\sigma} B = F_D(L), \tag{6}$$

$$a_X^{1-\sigma} \phi B^* = F_X(L^*), \tag{7}$$

$$a_D^{*1-\sigma} B^* = F_D(L^*), \tag{8}$$

$$a_X^{*1-\sigma} \phi B = F_X(L), \tag{9}$$

where $F_D \equiv \delta\sigma\widetilde{F}_D$, $F_X \equiv \delta\sigma\widetilde{F}_X$, $B = \frac{\mu L}{P^{1-\sigma}}$, $B^* = \frac{\mu L^*}{P^{*(1-\sigma)}}$, and $\phi \equiv \tau^{1-\sigma} \in [0,1]$ represents trade freeness. It is assumed that the fixed market entry cost (beachhead cost) increases in the size of the market $\frac{dF_D}{dL^j}, \frac{dF_X}{dL^j} > 0$. We will parametrize how the beachhead cost depends on market size below. Note, however, that it is natural that F depends on L, since the marketing costs of establishing a new brand in a large market, such as e.g. the US, are much higher than in a small country.

Finally, free entry ensures that the ex-ante expected profit of developing a new variety equals the investment cost in both countries:

$$\int_0^{a_D} \left(a_D^{1-\sigma} B - F_D(L)\right) dG(a) + \int_0^{a_X} \left(\phi a_X^{1-\sigma} B^* - F_X(L^*)\right) dG(a) = F_E, \tag{10}$$

$$\int_0^{a_D^*} \left(a_D^{*(1-\sigma)} B^* - F_D(L^*)\right) dG(a) + \int_0^{a_X^*} \left(\phi a_X^{*(1-\sigma)} B - F_X(L)\right) dG(a) = F_E. \tag{11}$$

2.2 Solving for the Long-run Equilibrium

We follow HMY in assuming that the probability density function is Pareto[4]:

$$G(a) = a^k. \tag{12}$$

Substituting the cut-off conditions (6), (7), (8), and (9) into the free-entry conditions (10) and (11) gives B, and B^*,

[4]This assumption is consistent with the empirical findings by Axtell (2001).

$$B=\left(\frac{F_E F_D^{\beta-1}(L)\cdot(\beta-1)\left(1-\Omega(L^*)\right)}{1-\Omega(L)\Omega(L^*)}\right)^{\frac{1}{\beta}} \tag{13}$$

$$B^*=\left(\frac{F_E F_D^{\beta-1}(L^*)\cdot(\beta-1)\left(1-\Omega(L)\right)}{1-\Omega(L)\Omega(L^*)}\right)^{\frac{1}{\beta}}, \tag{14}$$

where $\beta \equiv \frac{k}{\sigma-1} > 1$, and $\Omega(L^j) \equiv \phi^\beta \left(\frac{F_X(L^j)}{F_D(L^j)}\right)^{1-\beta} \in [0,1]$ is an index of trade costs.

Using (13), (14) and the cut-off conditions, gives the cut-off marginal costs:

$$a_D^k=\frac{(\beta-1)\,F_E}{F_D(L)}\left(\frac{(1-\Omega(L^*))}{1-\Omega(L)\Omega(L^*)}\right), \quad a_D^{*k}=\frac{(\beta-1)\,F_E}{F_D(L^*)}\left(\frac{(1-\Omega(L))}{1-\Omega(L)\Omega(L^*)}\right), \tag{15}$$

$$a_X^k=\frac{(\beta-1)\,\Omega(L^*)F_E}{F_X(L^*)}\left(\frac{(1-\Omega(L))}{1-\Omega(L)\Omega(L^*)}\right), \quad a_X^{*k}=\frac{(\beta-1)\,\Omega(L)F_E}{F_X(L)}\left(\frac{(1-\Omega(L^*))}{1-\Omega(L)\Omega(L^*)}\right). \tag{16}$$

From these it is seen that, contrary to the standard model by Melitz (2003), the market size will typically affect the cut-off marginal costs. We will assume that $\frac{F_X^j}{\Omega^j} > F_D^k$ for all j,k. As shown below, this assumption implies that $a_X^j < a_D^j \ \forall j$.

The price indices may be written as

$$P^{1-\sigma}=\frac{\beta}{\beta-1}\left(n a_D^{1-\sigma}+n^*\phi a_D^{*(1-\sigma)}\left(\frac{a_X^*}{a_D^*}\right)^{k+1-\sigma}\right), \tag{17}$$

$$P^{*(1-\sigma)}=\frac{\beta}{\beta-1}\left(n\phi a_D^{(1-\sigma)}\left(\frac{a_X}{a_D}\right)^{k+1-\sigma}+n^* a_D^{*(1-\sigma)}\right), \tag{18}$$

and the mass of firms in each country can be calculated using (13), (14), (15), and (16) together with the fact that $B=\frac{\mu L}{P^{1-\sigma}}$, and $B^*=\frac{\mu L^*}{P^{*(1-\sigma)}}$:

$$n=\frac{\mu\,(\beta-1)}{F_D(L)\beta}\frac{L\left(1-\Omega(L)\right)-L^*\Omega(L)\left(1-\Omega(L^*)\right)}{\left(1-\Omega(L)\Omega(L^*)\right)\left(1-\Omega(L)\right)} \tag{19}$$

$$n^*=\frac{\mu\,(\beta-1)}{F_D(L^*)\beta}\frac{L^*\left(1-\Omega(L^*)\right)-L\Omega(L^*)\left(1-\Omega(L)\right)}{\left(1-\Omega(L)\Omega(L^*)\right)\left(1-\Omega(L^*)\right)}. \tag{20}$$

Welfare may be measured by indirect utility, which is proportional to the real wage $\frac{w}{p_A^{1-\mu}P^u}$. Since $p_A = w = 1$, it suffices to examine P. Using (17), (15), (16), (19), and (20) we have

$$P=\left(\mu^{-\beta}L^{-\beta}F_D^{\beta-1}(L)F_E\,(\beta-1)\cdot\frac{1-\Omega(L^*)}{1-\Omega(L)\Omega(L^*)}\right)^{\frac{1}{\beta(\sigma-1)}}. \tag{21}$$

This expression shows that, as in the Melitz (2003) model, welfare always increases (P decreases) with trade liberalisation; that is with higher ϕ or lower $\frac{F_X}{F_D}$.

2.2.1 Parametrisation of the beachhead cost

In the following, we parametrise the beachhead costs as:

$$\widetilde{F}_D(L^j) = f_D + \left(L^j\right)^\gamma, \quad \widetilde{F}_X(L^j) = f_X + \left(L^j\right)^\gamma, \quad \gamma > 0. \tag{22}$$

The variable component of the beachhead cost increases in market size, while the constant term picks up costs that are independent of market size. It is quite natural that the beachhead cost would have one fixed and one variable component. The constant f could be the fixed cost of standardizing a product for a particular market or the cost of producing an advertisement tailored to a particular market with its culture and language. The variable cost term L^γ represents the fact that the cost of spreading an advertising message increases with the number of consumers targeted. For instance, the number of free product samples or advertising posters increases with the size of the population. Likewise, the cost of television advertising increases with the number of viewers. We do not put any restriction on the shape of the variable cost term except $\gamma > 0$.

3 Results

A large number of comparative static results may be derived. Here, we focus on the more novel aspects of our model, which are related to the effects of market size. From now on, the simplified notation $F_D^j \equiv F_D(L^j)$, $F_X^j \equiv F_X(L^j)$, and $\Omega^j \equiv \Omega(L^j)$ is adopted.

3.1 Productivity

The first set of results concerns the productivity of exporters and non-exporters in the two countries. From (6), and (7)

$$a_D^{\sigma-1} = \frac{B}{F_D}, \quad a_X^{\sigma-1} = \frac{\phi B^*}{F_X^*}. \tag{23}$$

A higher L^j affects the cutoffs via two channels: First, it changes the demand facing each firm (via B respective B^*) and, second, it increases the market size dependent beachhead costs.

The effect of the foreign market size on non-exporters

$$\frac{\partial a_D}{\partial L^*} < 0, \tag{24}$$

from (23), since $\frac{\partial B}{\partial L^*} < 0$ by inspection of (13). The intuition is that a larger foreign market implies a larger mass of foreign firms competing in the home market, which decreases the market shares of domestic non-exporters.

The effect of a larger home market on non-exporters is

$$\frac{\partial a_D}{\partial L} < 0 \quad \text{for} \quad \phi < 1, \tag{25}$$

as shown in appendix 6.2. The negative signs imply that the higher beachhead cost due to a larger market dominates the effect of higher demand.

Next, from (23)

$$\frac{\partial a_X}{\partial L} < 0, \tag{26}$$

since $\frac{\partial B^*}{\partial L} < 0$. A larger mass of domestic exporters implies stronger competition in the foreign market, and the marginal exporter must consequently be more productive.

The effect of foreign market size on the productivity of domestic exporters is, as shown in appendix 6.3, ambiguous:

$$\begin{aligned} \frac{\partial a_X}{\partial L^*} &\leq 0 \quad \text{for} \quad \psi^{\beta-1}\psi^{*(\beta-1)}\left(\beta-(\beta-1)\psi^*\right) \leq \phi^{2\beta} \\ \frac{\partial a_X}{\partial L^*} &> 0 \quad \text{for} \quad \psi^{\beta-1}\psi^{*(\beta-1)}\left(\beta-(\beta-1)\psi^*\right) > \phi^{2\beta}, \end{aligned} \tag{27}$$

where $\psi^j \equiv \frac{F_X^j}{F_D^j}$ measures relative market access (relative beachhead cost) of foreign versus domestic firms. The left-hand side of the inequality, determining the sign of the derivative, decreases in ψ^* as easily shown. This means that a_X will always decrease in the foreign market size when the relative beachhead cost in the foreign market is sufficiently high. Referring back to (23), a_X will fall when the effect from a higher beachhead cost dominates. For ψ^* close to one, on the contrary, the effect of larger sales dominates, which implies that the marginal exporter becomes less productive as the export market increases in size.

The effects of market size on the productivity of exporters and non-exporters are summarized in Result 1.

Result 1: The average productivity of exporters as well as non-exporters increases in the size of the domestic market as long as $\phi < 1$. The average productivity of non-exporters also increases in the size of the foreign market. The average productivity of exporters increases in the foreign market size if the beachhead cost of exporters is sufficiently higher than the beachhead cost of domestic firms in this market.

The next question is how the relative productivity of firms in the two countries is affected by market size. Note that the productivity of non-exporters in both countries increases as one of the markets grows. As shown in appendix 6.4

$$\left(\frac{a_D}{a_D^*}\right)^k = \frac{F_D^*}{F_D}\left(\frac{1-\Omega^*}{1-\Omega}\right) > 1 \quad for \quad L^* > L, \quad and \quad \Omega^*, \Omega < 1, \tag{28}$$

meaning that domestic producers are more productive in a larger economy. It is also the case that the productivity difference between domestic producers in the two economies increases with the difference in market size:

$$\frac{\partial\left(\frac{a_D}{a_D^*}\right)}{\partial L^*} > 0, \quad for \quad L^* > L, \quad and \quad \Omega^*, \Omega < 1, \tag{29}$$

as shown in appendix 6.1.

Result 2: Non-exporters in a large market are, on average, more productive than non-exporters in a smaller market, and this difference increases with the difference in country size.

Next using (15) and (16), the relative cut-off productivity for non-exporters and exporters in the home country is

$$\left(\frac{a_D}{a_X}\right)^k = \frac{F_X^*}{F_D\Omega^*}\left(\frac{1-\Omega^*}{1-\Omega}\right) > 1, \quad for \quad \frac{F_X^j}{\Omega^j} > F_D^k \, \forall j,k, \; and \quad \Omega^*, \Omega < 1. \tag{30}$$

There is strong empirical support for exporters being more productive than domestic firms, and we follow Melitz (2003) by making parameter assumptions for this to hold: $\frac{F_X^j}{\Omega^j} > F_D^k$.[5]

Finally, also the market size matters for the relative productivity of exporters to non-exporters, in accordance with the stylised evidence presented in the introduction:

$$\frac{\partial\left(\frac{a_D}{a_X}\right)}{\partial L} < 0 \quad for \quad \Omega < 1, \tag{31}$$

as shown in appendix 6.5. The larger is the home country, the less productive are exporters as compared to non-exporters. Essentially, the higher fixed cost associated with the larger home market will push up the relative productivity of domestic firms, which makes exporters look less productive in comparison.

Result 3: Exporters are more productive than producers for the domestic market. However, this effect decreases in the size of the home country.

3.2 Trade volume

The next set of results concerns the relationship between country size and manufacturing export share. A home exporting firm with marginal cost a, sells $a^{1-\sigma}\phi B^*$ in the foreign market. Using (7), the total export volume from home is

$$V_X = \int_0^{a_X} a^{1-\sigma} dG(a \mid a_D) \cdot \frac{F_X^*}{a_X^{1-\sigma}} = \left(\frac{a_X}{a_D}\right)^k \frac{\beta}{\beta-1} F_X^* n. \tag{32}$$

Similarly, the total production volume for the home market is

$$V_D = \int_0^{a_D} a^{1-\sigma} dG(a \mid a_D) \cdot \frac{F_D}{a_D^{1-\sigma}} = \frac{\beta}{\beta-1} F_D n. \tag{33}$$

The export share may now be written as

$$S_X = \frac{V_X}{V_X + V_D} = \frac{\Omega^*(1-\Omega)}{1-\Omega^*\Omega}. \tag{34}$$

Differentiating with respect to country size gives

[5] The corresponding condition in Melitz (2003) is that $\frac{F_X}{\phi} > F_D$.

$$\frac{\partial S_X}{\partial L} = \frac{\Omega^* (\Omega^* - 1)}{(1 - \Omega^* \Omega)^2} \frac{\partial \Omega}{\partial L} < 0, \tag{35}$$

$$\frac{\partial S_X}{\partial L^*} = \frac{1 - \Omega}{(1 - \Omega^* \Omega)^2} \frac{\partial \Omega^*}{\partial L^*} > 0, \tag{36}$$

which implies that a smaller country has a higher manufacturing export share than a larger one.

Result 4: The manufacturing export share of a country decreases in its own size, and increases in the trade partner's size.

Next, note that for $f_X = f_D$, $\Omega^* = \Omega = 1$. This means, from (34), that $S_X = S_X^*$; i.e., manufacturing export shares converge as f_X approaches f_D. Moreover, since a falling f_X makes exporting easier, export shares converge upwards.

Result 5: Falling relative beachhead costs (f_X converging to f_D) imply (upwards) converging manufacturing export shares.

The intuition for *Result 4* and *Result 5* derives from the fact that firms, when selling their product, have to pay two different sunk costs: a standardisation cost that is independent of market size (this could entail product standardisation as well as the design of a market specific marketing message) and a marketing cost which depends on the size of the market reflecting the higher cost of reaching more consumers. We also assume that standardisation for a particular market is more costly for an exporter than a domestic producer. Because the cost of standardisation is independent of market size, it becomes relatively less important compared to the marketing cost when the market is large. The difference in fixed costs between foreign and domestic firms is therefore relatively smaller in a large market.

For example, suppose that Sweden and the United States have similar levels of regulation but different tastes in design of labels, packages and instructions. Then the cost of standardisation is similar for an American firm targeting the Swedish market and for a Swedish firm targeting the American market. However, the market size dependent marketing cost is much higher for firms selling in the US compared to those selling in Sweden. The difference in fixed costs for Swedish exporters and American domestic producers, both serving the same market, is therefore smaller in relative terms than the difference between American exporters and Swedish domestic producers. Consequently the smaller country, Sweden, has a larger share of manufacturing exports in their production.

Second, since Swedish exporters are more concerned with the larger marketing costs than with the standardisation costs, compared to American exporters to Sweden, it must be that the decrease in standardisation costs for foreign markets (f_X approaching f_D) affects American firms more than Swedish. This means that American firms will increase exporting at a greater speed than the Swedish firms and therefore they will start to catch up with their Swedish counterparts. In the aggregate, the American export share of production will then approach the (larger) Swedish export share and export shares converge across countries. In the extreme, when the cost of standardisation does not depend at all on whether it is for the domestic or foreign market, market specific fixed costs are the same for all firms regardless of where they are based and the export shares converge completely across countries.

It may be useful to compare our results to the standard models. We use here the Melitz (2003) model with a homogenous good and freely traded A-sector a la Helpman et al. (2004). It is easy to show that the manufacturing export shares are independent of country size in this model without our assumption of a market size dependent beachhead cost. However, our result may also be compared to the standard Dixit-Stiglitz trade model without a homogenous good A-sector (see e.g. Helpman (1987)). Like our model, trade shares are negatively related to market size in this model. However, contrary to our model, manufacturing trade shares diverge as trade costs fall: trade shares increases from zero in autarky to the share of the foreign market in total demand at free trade.[6] As argued below, we believe that our prediction of converging manufacturing export shares is supported by empirical evidence.

4 Empirical Analysis

In this section, we empirically test several predictions of our model related to the effects of market size. These predictions should ideally be tested in a cross-country firm level data set, but this type of data is not yet available. To focus on the effects of market size, we use cross-country data rather than e.g. firm level data for an individual country. We work with the OECD's STAN industrial database which includes sectoral production and trade data for 27 manufacturing sectors in OECD countries from 1980 to 2003.

4.1 Country size and manufacturing export shares

We start by focusing on implications of the model related to country size and manufacturing export shares. First, we check that manufacturing export shares are negatively correlated with country size in our dataset, as predicted by Result 4.

Second, Result 5 states that the export share of the manufacturing sector across countries converges as the fixed component of the exporting beachhead cost, f_X, approaches the value for the fixed component of the domestic beachhead cost, f_D. Given that this has been happening over time, we should observe converging manufacturing trade shares over time. The assumption that the relative access cost to foreign markets, as compared to that of the domestic market, has been falling over time is very much in line with the often cited effect of globalization making the world more alike. A concrete example supporting this assumption is the process of product standardization and removal of non-tariff barriers to trade within the European Union during the last 20-30 years. GATT and WTO negotiations have also aimed at reducing nontariff barriers to trade during this period. Finally, the rapid improvement of telecommunications, including the internet, simplifies business contacts and information gathering about foreign markets, which may be interpreted as a fall in f_X.

[6] In this model, of course, there is no beachhead cost that can be affected by trade liberalization.

We look at the evolution of manufacturing export shares over time, on a sectoral level within the OECD using the STAN database with yearly observations from 1980 to 2003[7]. Accepting the assumption that the process of falling access costs to foreign markets has occurred gradually over time during the period investigated, we should observe converging manufacturing export shares. We apply four different methods of analysis as outlined in the following sections.

4.1.1 Country size and manufacturing export shares

Result 4 implies that large countries should have relatively lower manufacturing export shares than smaller countries. We investigate this by running the simple regression

$$s_{ist} = \beta_0 + \beta_1 l_{it} + \varepsilon_{ist}, \tag{37}$$

where $s_{ist} \equiv \log\left(\frac{X}{Y}_{ist}\right)$, $l_{it} \equiv \log L_{it}$. The regression is run at the sectoral level. Table 1 shows the regression of export shares over GDP on a sectoral level in 2001. The regression includes fixed effects for sectors. The coefficient for population, which can be interpreted as a standard elasticity, is highly significant and of the expected sign.

Year 2001

Dependent variable	$\frac{X}{Y}$
	(1)
l_{it}	-0.15***
	(0.024)
Sector dummies	Yes
Observations	595
R squared	0.43

Note: Standard errors in parentheses.
* significant at 10%
** significant at 5%
*** significant at 1%.

Table 1: Export Shares and Country Size

[7] We include all manufacturing sectors except those related to the extraction of raw materials since we do not believe that these are affected by the dynamics described in this paper.

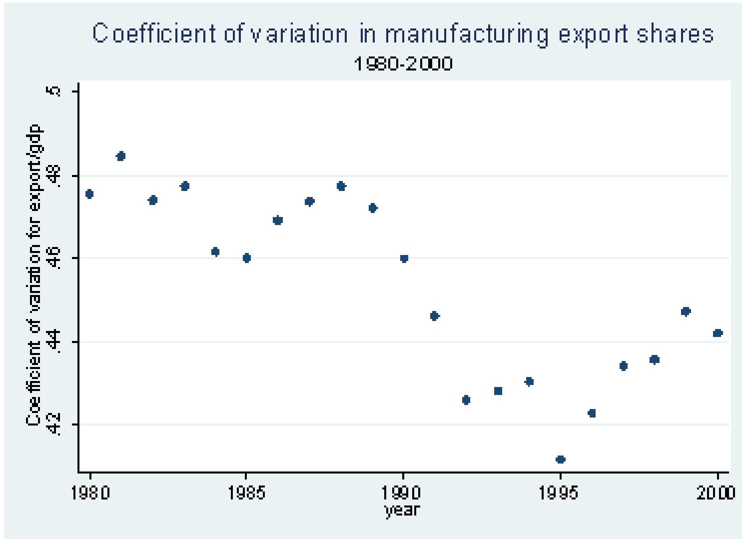

Figure 2: The coefficient of variation for country level export shares. Source: OECD STAN.

4.1.2 Convergence of manufacturing export shares

Next, we proceed to test Result 5 predicting an upward convergence in manufacturing export shares when f_X approaches f_D, and, as argued above, we assume time to be a good proxy for this process.

To begin with we explore graphically the data on manufacturing aggregated to the country level. We want a balanced panel so we only include country and sector pairs that have nonmissing data throughout the period 1980 to 2000 before we aggregate to the country level. For this period, there are data on most sectors for most countries througout. The appendix includes a list of the 18 countries that are included. First, Figure 2 plots the evolution of the coefficient of variation of the distribution of tradeshares (exports divided by output) for the sample of countries. We use the coefficient of variation since this is neutral to scale. The graph gives an indication that, on average, the average dispersion of tradeshares in manufacturing across countries decreases throughout the period. This result is driven by the fact that the mean grows more rapidly than the standard deviation over time. In Figure 3 we plot histograms of country level tradeshares for five equally spaced years in the period. Clearly, we see that the mean increases while a change in the absolute level of dispersion is more difficult to detect.

However, with the STAN sectordal data we are able to analyse the data also at the sectoral level and also to detect if it is the countries with the lowest initial tradeshares that experience the highest increases. We therefore proceed to a regression framework where we use three different techniques for analysing convergence.

The first approach is to simply regress the logged level of manufacturing export shares in a specific sector on a dummy, D_{ist}, which takes the value of 1 if that sector has a lower export share than the average, interacted with a time variable:

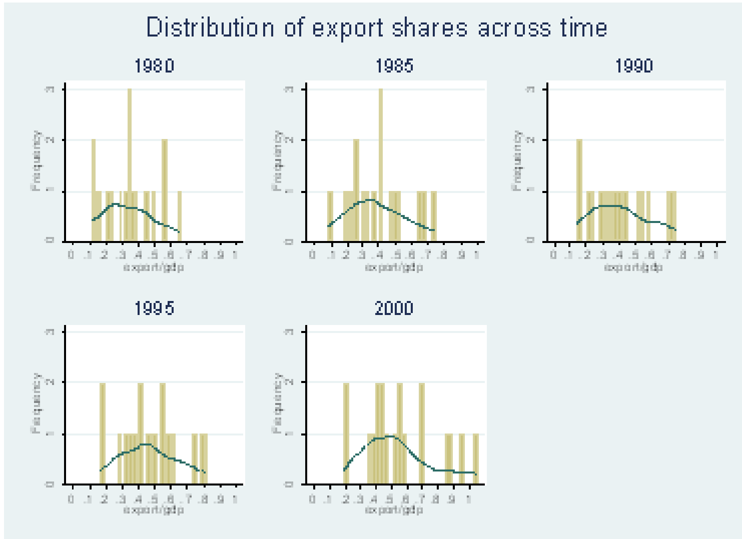

Figure 3: The mean country level export share. Source: OECD STAN.

$$s_{ist} = \beta_0 + \beta_1 l_{it} + \beta_2 D_{ist} + \beta_3 * t + \beta_4 * D_{ist} * t + \gamma \Gamma_s + \varepsilon_{ist}. \tag{38}$$

The implication of Result 5 it that we would find a positive value for β_4 (with fixed effects for all sectors, Γ_s), that is, that those countries with a sector below average tend to increase, on average, while the countries above do the opposite. The result is reported in Table 2. Errors are clustered around country and year pairs. The coefficient on the interacted variable is significantly positive as predicted, which indicates convergence on average over time. Moreover, the coefficient on t is significantly positive, consistent with upward convergence.

One source of convergence in export shares may simply be that countries are converging in size. This is controlled for by the term l_{it}. The negative and significant estimate for β_1 indicates that there is indeed some convergence due to converging population sizes.

Our second approach is to check for mean reversion in the manufacturing export share series by regressing the first difference in export shares on its own lagged value in levels:

$$\Delta s_{ist} = \beta_0 + \beta_1 s_{ist-1} + \beta_2 \Delta l_{it} + \beta_3 D_s + \varepsilon_{ist}, \tag{39}$$

with fixed effects for sectors, D_s. Also in this case do we cluster on country-year pairs. The model would predict a negative value of β_1 for convergence. To deal with the possibility of serially correlated errors, we also run regressions with lags up to the degree of $p = 3$[8]:

[8] To account for the possibility of the errors following an AR(1) process, we run a regression of the residuals from (40) in the following way

$$\widehat{\varepsilon}_{ist} = \rho \widehat{\varepsilon}_{ist-1} + u_{ist}$$

Years 1980 to 2003

Dependent variable	s_{ist}
	(1)
l_{it}	-0.045***
	(0.014)
D_{ist}	-44.8***
t	0.024***
$D_{ist} * t$	0.022***
	(0.005)
Sector dummies	Yes
Observations	11644
R squared	0.7

Note: Standard errors in parentheses. Errors are clustered on country and year pairs.

* significant at 10%

** significant at 5%

*** significant at 1%.

Table 2: CONVERGENCE (DUMMY APPROACH)

$$\Delta s_{ist} = \beta_0 + \sum_{i=1}^{p} \beta_{1i} s_{ist-i} + \beta_2 \Delta l_{it} + \beta_3 D_s + \varepsilon_{ist}. \tag{40}$$

Our model predicts that the sign of β_1 in (39) is negative. This means that the higher was the export share in the previous period, the less of an increase there is in the current period. The results are shown in Table 3. The sign on the first lag of the export share is negative and significant, suggesting convergence. The result is upheld also in the regressions with three lags, suggesting that serial correlation only produces a positive bias, if any.

Our third approach follows the standard empirical growth literature (see e.g. Barro and Sala-i-Martin (1991), Barro and Sala-i-Martin (1992), Bernard and Jones (1996), and Mankiw

increasing p in (40) by one each time. We find that there is evidence of ρ being positive and significant for $p = 1$ and 2 but not for $p = 3$. We therefore include three lags in Table 3.

Years 1980 to 2003

Dependent variable	Δs_{ist}	Δs_{ist}	Δs_{ist}
	(1)	(2)	(3)
s_{ist-1}	-0.035***	-0.036***	-0.11***
	(0.006)	(0.005)	(0.034)
Δl_{ist}		-0.10	0.43
		(1.36)	(1.26)
s_{ist-2}			0.053
s_{ist-3}			0.021
Sector dummies	Yes	Yes	Yes
Observations	10996	10996	9702
R squared	0.03	0.03	0.03

Note: Standard errors in parentheses. Errors are clustered on country and year pairs.

* significant at 10%

** significant at 5%

*** significant at 1%.

Table 3: Convergence (Lagged values)

et al. (1992)). We use the initial value of the manufacturing export share for which we have data and regress the average growth rate in export shares, $\widetilde{\Delta s}_{is}$, on the average growth rate of population and the initial level of trade shares, where the average growth rates are computed as the coefficient on the trend dummy in a regression of logged values on a constant and linear trend, see e.g. Bernard and Jones (1996):

$$\widetilde{\Delta s}_{is} = \beta_0 + \beta_1 s_{is0} + \beta_2 \widetilde{\Delta l}_i + \beta_3 D_s + \varepsilon_{is}.$$

The errors are clustered on the country level and sectors dummies are included. Once more, the model predicts that β_1 should be negative since the higher was the initial level, the lower would be the average change over time if convergence holds. In Table 4, it is seen that the growth rate of export shares depends negatively on the initial level in 1980, suggesting convergence within the OECD at the sectoral level.

For robustness, we have performed the same analysis as above also with five-year averages.

Years 1980 to 2002

Dependent variable	Δs_{ist}	Δs_{ist}
	(1)	(2)
$s_{i,1980}$	-0.020***	-0.018***
	(0.002)	(0.003)
Δl_i		1.009**
		(0.499)
Sector dummies	Yes	Yes
Observations	406	406
R squared	0.37	0.38

Note: Standard errors in parentheses. Errors are clustered on the country level.

* significant at 10%

** significant at 5%

*** significant at 1%.

Table 4: Convergence (Initial Values)

However, this does not alter the results in any of the regressions above.

4.2 Productivity and market size

Result 1 implies that the average productivity of non-exporters as well as exporters increases in the home market size. To see its implications on average overall (aggregate) productivity in the model, aggregate productivity is expressed as[9]:

$$\overline{\varphi} = \left(s_D \int_0^{a_D} a^{1-\sigma} dG(a \,|a_D\,) + s_X \int_0^{a_X} a^{1-\sigma} dG(a \,|a_D\,) \right)^{\frac{1}{\sigma-1}}, \tag{41}$$

where s_D is the share of home producers that sells domestically only and s_X is the share that exports. Since the ratio of exporters to non-exporters is $\left(\frac{a_X}{a_D}\right)^k$, $s_D = \frac{1}{1+\left(\frac{a_X}{a_D}\right)^k}$, and

[9] See Melitz (2003).

$s_X = \frac{\left(\frac{a_X}{a_D}\right)^k}{1+\left(\frac{a_X}{a_D}\right)^k}$, we can rewrite (41) as:

$$\overline{\varphi} = \frac{1}{a_D} \left(\frac{k}{k-\sigma+1} \right)^{\frac{1}{\sigma-1}} \left(\frac{1+\left(\frac{a_X}{a_D}\right)^{2k+1-\sigma}}{1+\left(\frac{a_X}{a_D}\right)^k} \right)^{\frac{1}{\sigma-1}}. \tag{42}$$

From (42), it is seen that average productivity increases in L since from (25) $\frac{\partial a_D}{\partial L} < 0$, from (31) $\frac{\partial\left(\frac{a_X}{a_D}\right)}{\partial L} > 0$, and $k - \sigma + 1 > 0$.

Therefore, we arrive at the prediction that aggregate productivity in manufacturing increases in country size, mainly due to the fact that both domestic and foreign producers face a higher beachhead cost in the larger market, which restricts sales to this market to the most productive firms. To test this prediction, we run the following regression[10]:

$$\log \widetilde{\varphi}_{ist} = \beta_0 + \beta_L \log L_{it} + \beta_K \log K_{ist} + \beta_D \log D + \varepsilon_{ist}. \tag{43}$$

Here, $\widetilde{\varphi}_{ist}$ denotes aggregate labour productivity in country i in sector s and year t. L_{it} is the national population size of country i in year t. K_{ist} is the amount of capital used and D is a set of dummies that will be explained.

We control for sectors by using the set D_s in all regressions, since f_D, f_X, and γ are expected to vary among sectors. Table 5 reports the estimated coefficients for a regression done only for the year of 2002, since this is the most recent year for which there is much data. This analysis captures cross-sectional effects of population on productivity. We use two measures of labour productivity: (1) output divided by employment and (2) value added divided by employment.[11] Population is used as **a** measure of country size when estimating the effect of country size on productivity. This is because population can be considered an exogenous variable for our purposes and, second, it is consistent with the treatment of country size in our model. Were we instead to use GDP, for example, this would depend both on population size and aggregate productivity. Errors are clustered on country and year pairs. The results are according to the model. Table 5 shows that, on average across sectors adjusted for sectoral dummies, labour productivity is higher in larger countries.

To also look at other years, we plot in Figure 4 and Figure 5 the specific values of β_L over time with a 95% confidence interval around it, starting in 1980 for the regression in columns (3) and (4). Figure 4 shows that the coefficient is positive and significant over time when capital in not included. In Figure 5, where capital is included, population is insignificant except in

[10] Pavcnik (2002) uses the semiparametric method from Olley and Pakes (1996) to estimate productivity. However, we do not have any firm level data which would be required for this method.

[11] A problem is that employment is reported by different countries in different (but similar) ways. We will use the standard measure that covers most countries, which is called total employment in the database.

Year 2002

Dependent variable	$\frac{\text{Output}}{\text{Worker}}$	$\frac{\text{Output}}{\text{Worker}}$	$\frac{\text{V.A.}}{\text{Worker}}$	$\frac{\text{V.A.}}{\text{Worker}}$
Units	Values	Values	Values	Values
	(1)	(2)	(3)	(4)
Population	0.206***	0.538***	0.221***	0.668***
	(0.100)	(0.246)	(0.100)	(0.255)
Capital		0.770***		0.666***
		(0.287)		(0.297)
Sector dummies	Yes	Yes	Yes	Yes
Observations	382	77	384	77
R squared	0.07	0.61	0.06	0.57

Note: Standard errors in parentheses. Errors are clustered on country and year pairs.

* significant at 10%

** significant at 5%

*** significant at 1%.

Table 5: Productivity and Country Size (Values)

2002. The regressions including capital should be interpreted with caution, however. First, when including capital, the sample shrinks to only seven countries. Moreover, there is an obvious endogeneity problem associated with capital, since it would tend to accumulate in more productive locations.

Finally, Table 6 displays regressions with country dummies to use within country variation in population size and test whether such variation affects aggregate productivity differently than cross-sectional differences in population. Here, the population turns out to be significant in all specifications.

We interpret our results as being consistent with firms being more productive in large markets. This is also consistent with e.g. Syverson (2004, 2006) who finds a positive association between productivity and market density using firm level data.

Naturally, an alternative explanation for the observed higher productivity in larger countries is that we are picking up productivity spillovers or agglomeration rents in line with e.g. the new economic geography models (See e.g. Krugman (1991), and Krugman and Venables (1995)).

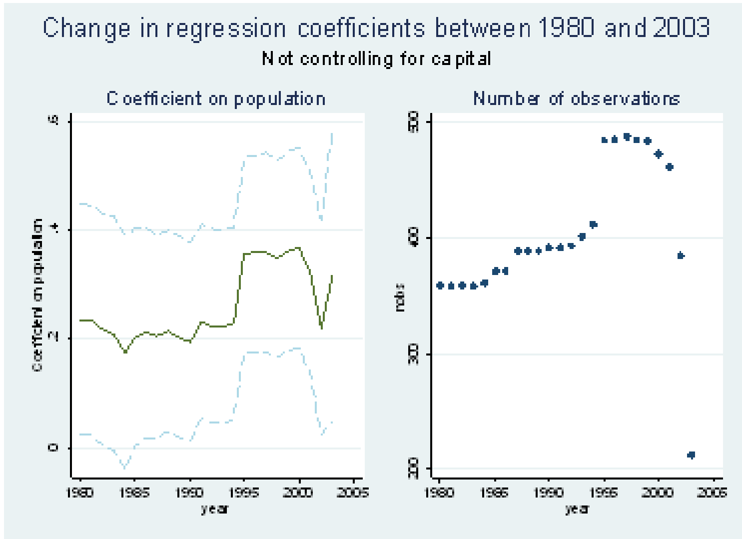

Figure 4: Regression of productivity on population at the sectoral level, with 95% confidence interval. Sector dummies are used. Source: OECD.

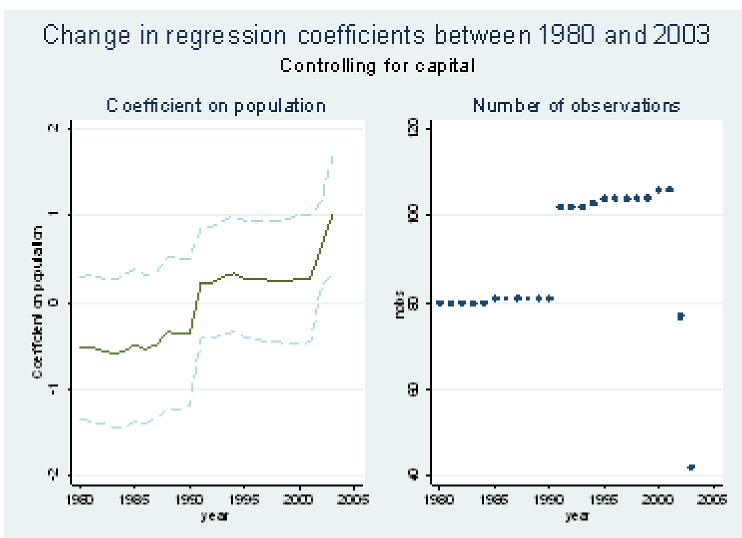

Figure 5: Regression of productivity on population at the sectoral level controlling for capital, with 95% confidence intervals. Sector dummies are used. Source: OECD.

Years 1980 to 2003

Dependent variable	$\frac{\text{Output}}{\text{Worker}}$	$\frac{\text{Output}}{\text{Worker}}$	$\frac{\text{V.A.}}{\text{Worker}}$	$\frac{\text{V.A.}}{\text{Worker}}$
Units	Volumes	Volumes	Volumes	Volumes
	(1)	(2)	(3)	(4)
Population	7.021***	9.33**	2.462***	2.876**
	(0.358)	(0.707)	(0.212)	(0.229)
Capital		0.099*		0.405***
		(0.055)		(0.031)
Dummies				
Country and sector	Yes	Yes	Yes	Yes
Observations	3876	1015	6036	2083
R squared	0.98	0.99	0.97	0.97

Note: Standard errors in parentheses. Errors are clustered on country and year pairs.

* significant at 10%

** significant at 5%

*** significant at 1%.

Table 6: Productivity and Country Size (Volumes)

However, empirical studies do not show any clear pattern of agglomeration in OECD data during the period of interest (See e.g. Knarvik and Overman (2002)). More importantly, agglomeration of the manufacturing sector in large countries would imply that manufacturing export shares increase in small countries and decrease in large ones. That is, such a scenario would imply diverging manufacturing export shares, which is not consistent with our theoretical model, and is rejected by our empirical results.

5 Conclusion

This paper has explicitly modelled a market size dependent market access or beachhead cost in the heterogenous firms and trade model by Melitz (2003). We model this cost as having one variable component that increases in market size, and one fixed component. The fixed component could e.g. be interpreted as the cost of standardizing a product for a particular market, while the variable cost term e.g. represents that the advertising cost of introducing a new product increases with the size of the market (number of consumers).

The introduction of market size dependent beachhead costs leads to a number of new results. The productivity of non-exporter as well as exporter firms will depend on market size, and so will manufacturing export shares. In particular, we show that non-exporter firms in a large market are more productive than non-exporters in a smaller market. Second, as in the standard model, exporters are more productive than non-exporters, but this productivity premium decreases in the size of the home country. Finally, we show that the manufacturing export share of a country decreases in its own size, and increases in the trade partner's size. This last effect decreases as markets are integrated (in the sense that the fixed beachhead cost of foreign markets declines). Accepting that market access costs into foreign markets have been falling over time as a result of globalisation, the model predicts converging manufacturing export shares over time.

In the empirical section, we focus on testing results related to country size, which are new compared to the standard model. We therefore use cross-country data. First, it is shown how manufacturing export shares are negatively correlated with market size, in accordance with the model. Second, a number of tests generate support for the model generated hypothesis that manufacturing export shares should converge over time. Finally, it is shown how average productivity is generally positively correlated with country size, as predicted by the model.

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6 Appendix

6.1 $\frac{\partial}{\partial L^*}\left(\frac{a_D}{a_D^*}\right)^k > 0$ for $\Omega^*, \Omega < 1$

Proof:

From (28)

$$\left(\frac{a_D}{a_D^*}\right)^k = \frac{F_D^*}{F_D}\left(\frac{1-\Omega^*}{1-\Omega}\right).$$

Differentiating w.r.t. L^* gives:

$$\frac{\partial}{\partial L^*}\left(\frac{F_D^*}{F_D}\left(\frac{1-\Omega^*}{1-\Omega}\right)\right) = \frac{\gamma L^{*\gamma-1}}{F_D\left(1-\Omega\right)}\left(1-\Omega^*-\left(\beta-1\right)\Omega^*\left(1-\Omega^{*\frac{1}{\beta-1}}\phi^{\frac{\beta}{1-\beta}}\right)\right). \tag{44}$$

The sign of the derivative depends on the sign of the term:

$$\left(1-\Omega^*-\left(\beta-1\right)\Omega^*\left(1-\Omega^{*\frac{1}{\beta-1}}\phi^{\frac{\beta}{1-\beta}}\right)\right). \tag{45}$$

The first- and second-order conditions for a minimum of this term w.r.t. $\Omega\left(L^*\right)$ are:

$$\begin{aligned} \frac{\partial}{\partial\Omega^*}\left(\Omega^*\left(1+\left(\beta-1\right)\left(1-\Omega^{*\frac{1}{\beta-1}}\phi^{\frac{\beta}{1-\beta}}\right)\right)\right) &= \beta\left(\Omega^{*\frac{1}{\beta-1}}\phi^{\frac{\beta}{1-\beta}}-1\right)=0 \\ \frac{\partial^2}{\partial^2\Omega^*}\left(\Omega^*\left(1+\left(\beta-1\right)\left(1-\Omega^{*\frac{1}{\beta-1}}\phi^{\frac{\beta}{1-\beta}}\right)\right)\right) &= \frac{\beta}{\beta-1}\Omega^{*\frac{1}{\beta-1}-1}\phi^{\frac{\beta}{1-\beta}}>0. \end{aligned} \tag{46}$$

The minimum is, thus, given by $\Omega^* = 1$ (since $\Omega^* = 1 \Longleftrightarrow \phi = 1$). Substituting $\Omega^* = 1$ into (44) gives $\frac{\partial}{\partial L^*}\left(\frac{a_D}{a_D^*}\right)^k = 0$. Consequently, it must be the case that $\frac{\partial}{\partial L^*}\left(\frac{a_D}{a_D^*}\right)^k > 0$ for $\Omega^*, \Omega < 1$.

6.2 $\frac{\partial a_D^j}{\partial L^j} < 0$

From (6.1), we have that

$$\frac{\partial\left(\frac{a_D}{a_D^*}\right)}{\partial L^*} = \frac{\partial a_D}{\partial L^*}\frac{1}{a_D^*} - \frac{a_D}{\left(a_D^*\right)^2}\frac{\partial a_D^*}{\partial L^*} > 0. \tag{47}$$

Since from (15) $\frac{\partial a_D}{\partial L^*} < 0$, (47) holds iff $\frac{\partial a_D^*}{\partial L^*} < 0$

6.3 $\frac{\partial a_X}{\partial L^*}$

From (16)

$$a_X^k = \frac{(\beta-1)\,\Omega^* F_E}{F_X^*}\left(\frac{(1-\Omega)}{1-\Omega\Omega^*}\right) = (\beta-1)\,F_E(1-\Omega)\frac{1}{F_X^*(\frac{1}{\Omega^*}-\Omega)}. \tag{48}$$

The sign of $\frac{\partial a_X}{\partial L^*}$ is therefore determined by the sign of

$$\begin{aligned} & \frac{\partial}{\partial L^*}[F_X^*(\frac{1}{\Omega^*}-\Omega)] & (49)\\ = & \frac{\partial}{\partial L^*}[F_X^{*\beta}F_D^{*1-\beta}\phi^{-\beta}-F_X^*\Omega]. & (50)\end{aligned}$$

Now

$$\begin{aligned} \frac{\partial}{\partial L^*}[F_X^{*\beta}F_D^{*1-\beta}\phi^{-\beta}-F_X^*\Omega] &\lesseqgtr 0 \\ &\Leftrightarrow \\ \left(\frac{F_X^*}{F_D^*}\right)^\beta\left(\beta\frac{F_D^*}{F_X^*}-(\beta-1)\right) &\lesseqgtr \Omega\phi^\beta \\ &\Leftrightarrow \\ \beta-\frac{F_X^*}{F_D^*}(\beta-1) &\lesseqgtr \Omega\Omega^*. \end{aligned}$$

6.4 $\left(\frac{a_D}{a_D^*}\right)^k > 1$ iff $L^* > L$ for $\Omega^*, \Omega < 1$

Proof:

First

$$L^* = L \Longleftrightarrow \left(\frac{a_D}{a_D^*}\right)^k = \frac{F_D^*}{F_D}\left(\frac{1-\Omega^*}{1-\Omega}\right) = 1.$$

That $L^* = L \Longleftrightarrow \left(\frac{a_D}{a_D^*}\right)^k > 1$ for $\Omega^*, \Omega < 1$ now follows from $\frac{\partial}{\partial L^*}\left(\frac{a_D}{a_D^*}\right)^k > 0$ for $\Omega^*, \Omega < 1$.

6.5 $\frac{\partial\left(\frac{a_D}{a_X}\right)}{\partial L} < 0 \quad for \quad \Omega < 1$.

Proof:

$$\frac{\partial}{\partial L}\left(\frac{a_D}{a_X}\right)^k = \gamma L^{\gamma-1}\frac{F_X^*}{F_D^2}\frac{(1-\Omega^*)}{\Omega^*(1-\Omega)}\left((\beta-1)\frac{\Omega\left(1-\frac{F_D}{F_X}\right)}{(1-\Omega)}-1\right). \tag{51}$$

The sign of (51) will depend on the sign of the term:

$$\Theta \equiv \left(\frac{(\beta-1)\,\Omega\left(1-\frac{F_D}{F_X}\right)}{(1-\Omega)}-1\right) \tag{52}$$

The F.O.C. when maximising Θ w.r.t. ϕ is:

$$\frac{(\beta-1)\,\beta\Omega\left(1-\frac{F_D}{F_X}\right)}{\phi\,(1-\Omega)} - \frac{(\beta-1)\,\beta\Omega^2\left(1-\frac{F_D}{F_X}\right)}{\phi\,(1-\Omega)^2} = 0 \Longleftrightarrow 1-\frac{\Omega}{(1-\Omega)} = 0. \tag{53}$$

So the only stationary point is $\Omega = 1$. Furthermore, $\Theta(\Omega = 0) = -1$ and $\lim_{\Omega(L)\to 1} \Theta = 0$. Therefore, it follows that for $\Omega \in [0,1)$:

$$\frac{d}{dL}\left(\frac{a_D}{a_X}\right)^k < 0.$$

6.6 Countries included in Figure 3.

The following countries are included in Figure 3. This is a subset of the full STAN sample but it is the only set of countries for which there is data for the full length of 1970 until 2002.

Austria
Belgium
Canada
Denmark
Finland
France
Iceland
Ireland
Italy
Japan
Netherlands
New Zealand
Norway
Portugal
Spain
Sweden
United Kingdom
United States.