# Economies of Scale and the Volume of Intra-Industry Trade*


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## Abstract


We show that an increase in the degree of economies of scale raises the volume of intra-industry trade and the share of trade in total production in a model of monopolistic competition with traded and non-traded goods. This confirms the view that technological changes might have contributed to the high growth rate of trade observed during the post-war period.



Key Words: Trade volume, economies of scale

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## 1. Introduction

The purpose of this note is to show that the presence of endogenously determined non-traded products in a standard model of intra-industry trade is useful to derive the empirically relevant result that a higher degree of economies of scale increases the volume of trade and the share of trade in total production.

It is common knowledge that intra-industry trade requires the presence of economies of scale at the firm level (and of product differentiation) to exist. Krugman (1979, 1980) made this point twenty years ago and his seminal articles have spawned an entire literature. However, a usual criticism of the standard workhorse model (i.e., Krugman, 1980) is that economies of scale have no effects on the volumes of both production and trade. Harrigan (1994), however, finds evidence that the volume of trade is higher in sectors with larger scale economies. In this paper, we show how economies of scale can positively influence the volume of trade by introducing non-traded goods in a standard monopolistic competition model of intra-industry trade.

We assume that firms differ in the fixed cost of exporting they face so that the number of trading and of non-trading firms becomes determined endogenously. We model then an increase in the degree of economies of scale by increasing the total fixed cost of production and thus by lowering the ratio of marginal to average costs for all the firms. We show how this leads to an increase in the number of trading firms as well as an increase of the volume of trade. The model also predicts that an increase in economies of scale leads to a higher share of trade relative to total production. This is an important result because it indicates that technological changes can contribute to the growth of world trade without relying on arguments such as outsourcing as in Hummels et al. (1999).

## 2. The Model

Consider the standard model of intra-industry trade with horizontal differentiation among final goods à la Krugman (1980). There are two identical countries, Home (d) and Foreign (f). Consumers in each country have identical preferences and the utility of each of these consumers is represented by

$$U = \sum_i c_{id}^q + \sum_j c_{jd}^q + \sum_l c_{lf}^q \ , \ q \in (0,1) , \tag{1}$$

where $c_{id}$ is the consumption of traded good *i*, $c_{jd}$ is the consumption of non-traded good *j*, and $c_{lf}$ is the consumption of imported good $l$. Consumer's income is the sum of individual labor income and the share of the profits from all domestic firms.

On the supply side, labor is the only factor of production, with $L=L_d=L_f$, and each worker supplies one unit of labor. Production of any differentiated goods requires a fixed cost $a$ and a constant unit cost $b$, both expressed in terms of labor. To export, a firm incurs two additional costs: a firm-specific fixed cost of export, $g_i \geq 0$ also expressed in terms of labor, and an international barrier to trade such that, if $t$ =1+t >1 units are shipped abroad, only one unit arrives, where *t* represents the per-unit barrier to trade. Below we call it transport cost although *t* represents all trade costs.

The firm-specific fixed cost of exporting creates an asymmetry between trading and non-trading firms. We assume that $g_i$ is distributed according to the density function $f(.)$ with support $[0, g_{n_a}]$, where $n_a$ is the autarkic number of goods produced in this market. We assume this distribution is the same in both countries and we use $\Phi(.)$ to denote the cumulated density function. To allow that some firms trade and other do not, we assume that $g_i$ is distributed in such a way that firms with high cost of exporting do not find profitable to engage in international trade. It follows that, in equilibrium, an exporter's profit, $p_i$, is necessarily non-negative.[1]

Since there are two types of firms: trading and non-trading firms, consider first the non-trading firms. Each of them maximizes

(2) $$p = p_d x_d - (a + b x_d) w,$$

with respect to $x_d$. A non-trading firm follows therefore the standard Lerner pricing rule,

(3) $$p_d = wb\,(1 - \frac{1}{e})^{-1},$$

where *w* is the wage rate and ε is the price elasticity of demand. Maximizing (1) with respect to $c_{id}$ and to $c_{lf}$, it is easy to establish that ε=1/1-θ whether a product is domestic or foreign, at least when the number of products is large. With free entry, there is zero-profit among non-trading firms and their individual production is thus

(4) $$x_d = \frac{aq}{b\,(1-q)}.$$

If it happens that all the firms are non-trading, the total number of goods produced in each country is determined by the resource constraint $L = n_a (a + b x_d)$. Hence, the autarkic number of goods is $n_a = L(1-q)/a$.

Consider now a trading firm. Firm *i* supplies $x_{id}$ units of its good to the domestic market and $x_{if}$ units to the foreign market, so that firm *i's* total labor requirement is

(5) $$l_i = a + b x_{id} + g_i + b t x_{if},$$

and its profit is

(6) $$p_i = p_{id} x_{id} + p_{if} x_{if} - (a + b x_{id} + g_i + b t x_{if}) w.$$

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[1] Montagna (1998) generates differences in profits by introducing heterogeneous marginal costs of production. Empirically, profitability differences among firms could be found in Cubbin and Geroski (1987) and Mueller (1990). See also Bernard et al. (2000), Bernard and Jensen (1998), and Roberts, Sullivan and Tybout (1995) for empirical analyses about the importance of heterogeneity among firms participating or not to export markets.

Maximizing (6) with respect to $x_{id}$ and $x_{if}$, it is easy to establish that $p_{id}$ also satisfies (3) and that $p_f = tp_d$ , where, by symmetry, we have dropped the notation for individual firm.

The production of a trading firm is found as follows. First, observe that consumers make no difference between a domestic product sold by a trading firm and one sold by a non-trading firm. Since they are all sold at the same price, the total domestic production of each trading firm is also given by (4). Second, utility maximization requires that, in equilibrium, individual consumption satisfies the ratio $c_d^{q-1} \big/ c_f^{q-1} = 1\!/t$ . This implies that $x_f = t^{\,q/q-1} x_d$ .

It is now easy to characterize the fixed cost of exporting for the firm which is just indifferent between trading and selling at home only. This critical rate, denoted by $\tilde{g}$ , is such that a firm earns zero profit on the export market. Solving $p_{if}\, x_{if} - (\tilde{g} + btx_{if})w = 0$ ,

(7) $$\tilde{g} = a\,t^{\,q/(q-1)} .$$

This is an important relationship for at least two reasons. First, it is easy to show that $g_i \le \tilde{g}$ corresponds to the condition that the total average cost of an exporting firm is lower or equal to the average cost of the non-trading firm. Thus, in the present model, an exporting firm exploits economies of scale at least as well as a non-trading firm.[2] Second, and more importantly, this relationship indicates that any change in transport cost or in the fixed cost of production affects $\tilde{g}$ and thus the number of traded goods $n_a \Phi(\tilde{g})$ . The fact that the number of traded goods increases with lower barriers to trade is, of course, not surprising. Simply, since the direct cost of exporting decreases, the marginal non-trading firms find profitable to export their product.[3] It is more surprising that the number of traded goods increases with the fixed cost of production. The intuition is the following. An increase in α must decrease the total number of products available to consumers since more resources have to be devoted to fixed costs. Given the utility function, each consumer increases its consumption of every surviving

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[2] This contrasts with the standard model in which firms exploit economies of scale equally well in autarky and in free trade.

[3] See Schmitt and Yu (2000) for the implications of this result.

product, including foreign products. Since prices do not depend on α, the firms which were just indifferent between trading and non-trading before the increase in α, must earn now a profit. This induces some firms with a higher fixed cost of exporting to engage in trade.[4] In other words, the additional resources required by a higher α come from non-trading firms, not from the trading firms as the relative cost of exporting declines with α.

This result implies that a change in technology and in particular one involving an increase in the degree of economies of scale through a higher fixed cost relative to the unit cost of production can induce more trade. Changes in technologies aimed first at exploiting economies of scale and more recently at economies of scope are often captured by increases in fixed costs relative to variable costs. To the extent that these changes have occurred over the post-WWII period and that they have been significant, our model predicts that they also have contributed to the increase in the volume of international trade.

We now derive the precise relationship between α and the volume of trade as well with the share of trade in total production.

## 3. Changes in Technology and Volume of Trade

We define the volume of trade as the volume of exports and thus as

$$T = n_\alpha \Phi(\tilde{\gamma};\alpha)x_f \,, \tag{8}$$

where $n_\alpha \Phi(\tilde{\gamma};\alpha)$ is the number of traded goods that depends on the critical fixed cost which in turn depends on the level of the fixed cost of production. Differentiating (8), the overall effects on export volume of a change in α are

$$\frac{dT}{T} = [\frac{\alpha}{n_\alpha}\frac{dn_\alpha}{d\alpha} + \frac{\alpha}{\Phi}\frac{d\Phi(\tilde{\gamma};\alpha)}{d\alpha} + \frac{\alpha}{x_f}\frac{dx_f}{d\alpha}]\frac{d\alpha}{\alpha} \,,$$

[4] This is quite different from the standard model since, an increase in the fixed costs of production does not change the total volume of trade. Simply, an increase in $\alpha$ raises output and export of an individual firm but it lowers the total number of products/firms and these two effects have exactly the same magnitude.

where the two first terms capture the effect that a change in α affects the benchmark number of firms and the distribution Φ. Using (7) and (4), it is straightforward to show that the first term is equal to –1 and the last term is equal to 1. Hence,

$$(9) \qquad \frac{dT}{T} = \frac{a}{\Phi}\left(f\frac{d\tilde{g}}{da} + \frac{\partial\Phi}{\partial a}\right)\frac{da}{a} > 0,$$

since an increase in $a$ increases the value of $\tilde{g}$ and that of Φ (i.e., $\partial\Phi(g,a)/\partial a > 0$). That is, an increase in the fixed cost of production unambiguously increases the volume of trade.

We now investigate how an increase in the fixed cost of production affects the share of trade in total production. To do so, we need to determine the effect of a change in α on production. Notice that to find changes in production, we only need to consider the changes in fixed costs of production and of export since total resources are necessarily devoted to cover either the fixed costs or production (including transport costs). Thus, we ask what is the change in production that must accompany the change in the total fixed costs of production and export, or

$$(10) \qquad \frac{dP}{da} = \frac{1}{b}\left\{\frac{d(na)}{da} + \frac{d}{da}\left[n_a\int_0^{\tilde{g}} gf(g)dg\right]\right\},$$

where n is the equilibrium number of firms, which is obtained from the labor market equilibrium:

$$(11) \qquad L = n(a + bx_d) + n_a\left(\int_0^{\tilde{g}} gf(g)dg + \Phi(\tilde{g})btx_f\right).$$

Using (11), we can show that (10) can be written as

$$(12) \qquad \frac{dP}{da} = \frac{1}{b}\left\{(q-1)\frac{d}{da}\left[n_a\int_0^{\tilde{g}} gf(g)dg\right] - q\frac{d(\tilde{g}n_a\Phi(\tilde{g}))}{da} + \frac{d}{da}\left[n_a\int_0^{\tilde{g}} gf(g)dg\right]\right\}$$

$$= \frac{q}{b}\left\{\frac{d}{da}\left[n_a\int_0^{\tilde{g}} gf(g)dg\right] - \frac{d(\tilde{g}n_a\Phi(\tilde{g}))}{da}\right\}$$

$$= -\left(\frac{q}{b}\right)\frac{d}{da}\left[n_a\int_0^{\tilde{g}}\Phi(g)dg\right]$$

Unfortunately, we cannot sign dP/d$a$ with a general distribution function $\Phi$. An increase in $a$ lowers the equilibrium number of firms, which tends to increase production since the fixed costs of the exiting firms are saved. However, the fixed cost of production of the surviving firms is now higher. Moreover, the total fixed costs of export are also higher since more firms become exporters. Intuitively, the last two effects should dominate the first one, and hence the total output should decrease with respect to an increase in $a$. This reasoning is indeed correct for a uniform distribution function $\Phi$.

If $g_i$ is uniformly distributed, $\Phi(g) = g / g_{n_a}$ (where $g_{n_a}$ is the fixed cost of export such that all firms are non-trading), so that $\int_0^{\tilde{g}} \Phi(g) dg = \frac{\tilde{g}^2}{2g_{n_a}}$. Since $\tilde{g} = a t^{q/(q-1)}$ and $a = L(1-q)/n_a$, it follows that

$$n_a \int_0^g \Phi(g) dg = \frac{L^2 (1-q)^2 t^{2q/(q-1)}}{2 n_a g_{n_a}}.$$

Substituting this expression in (12), we get

$$\frac{dP}{da} = -\left(\frac{qL^2 (1-q)^2 t^{2q/(q-1)}}{2b}\right) \frac{d}{da}\left(\frac{1}{n_a g_{n_a}}\right) < 0,$$

since $n_a$ and $g_{n_a}$ are decreasing in $a$. That is, an increase in the fixed cost $a$ reduces total production.[5]

The implication of the model is thus clear: by increasing trade and decreasing production, an increase in the degree of economies of scale of production also contributes to the observed increase in the share of trade in total production.

## 4. Conclusion

In this paper, we have shown that, unlike in the standard model of intra-industry trade, the volume of intra-industry trade and the share of trade in total production increase with the degree of economies of scale when one allows firms' heterogeneity with respect to export markets and in particular that some differentiated products are non-traded. If it is true that degrees of economies of scale have increased through time during the post-war period, then the above conclusions also hold in a dynamic context with respect to the growth rate of world trade and to the growth rate of the gap between trade and output.[6]

In a recent paper, Krugman (1995) argues that the causes of the growth in world trade are surprisingly disputed. While some favor trade liberalization and falling transportation costs, others argue that income growth and countries' income convergence are key. A third group underlines the role of technological changes and in particular the forces leading to outsourcing.[7] This paper argues that technological changes leading to higher degrees of economies of scale might also contribute to the post-war trade growth as well as the observed gap between the growth of world trade and world output. Although we are not aware of direct evidence that changes in economies of scale have affected the growth rate of trade, Harrigan (1994)'s result that the volume of trade tends to be higher in sectors with larger scale economies provide an indication that this force is strong enough to be pick up at the sectoral level.

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[5] Of course, there are other factors that increase world production but they are ruled out in this model.
[6] On this issue, see Rose (1991), Harris (1993) and WTO (2000).
[7] See Baier and Bergstrand (1999) for a recent empirical attempt to disentangle some of these forces.

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