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

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July 2001

Abstract

Using a model of monopolistic competition with traded and non-traded goods, this paper establishes a positive link between scale economies, the volume of intra-industry trade and the share of trade in total production. These results are consistent with empirical findings.

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1. Introduction

The main contribution of this note is to establish a positive causal link between the degree of economies of scale and the volume of intra-industry trade as well as with the share of industry trade in total production. These links are obtained by introducing traded and non-traded goods into the workhorse model of intra-industry trade.

It is well known that the presence of scale economies is an important ingredient for the existence of intra-industry trade in differentiated products.[1] Krugman made this point twenty years ago and his seminal articles have spawned an entire literature. However, the workhorse model of the literature on intra-industry trade (i.e., Krugman, 1980) predicts that, in equilibrium, the industry volumes of production and trade are *independent* of the degree of scale economies.[2] Indeed, although an increase in the degree of scale economies (through an increase in fixed cost) raises an individual firm's output and export, it decreases the number of firms and these two effects have exactly the same magnitude. Recognizing this absence of continuous causal relationship between volume of trade and magnitude of scale economies, Harrigan (1994) qualifies as purely `descriptive' his regressions linking these two variables but finds that the volume of trade is larger in industries where there are larger scale economies. His widely quoted results are believed to capture important empirical regularities.[3] The present paper is best interpreted as establishing a robust continuous causal relationship between volume of trade and degrees of scale economies.

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[1] Note there is a recent literature arguing that increasing returns are not necessary for intra-industry trade; see Davis (1995) and Bernhofen (2001).

[2] An early paper by Krugman (1979) does not have this shortcoming but has few applications in the literature due to the general functional form for preferences. On the link between volume of trade and preferences, see Markusen (1995).

In the next Section, we develop a model of monopolistic competition where firms face different fixed cost of exporting, allowing some of them to trade and others to sell at home only. In Section 3, we show how an increase in the degree of economies of scale increases the number of trading firms, the volume of trade, as well as the share of industry trade in total production.

2. The Model

Consider the standard model of intra-industry trade 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 them is represented by

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

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 α and a constant unit cost β, both expressed in terms of labor. To export, a firm incurs two additional costs: a firm-specific fixed cost of export, $\gamma_i \geq 0$ also expressed in terms of labor, and an international barrier to trade such that, if $\tau = 1+t > 1$ units are shipped abroad, only one unit

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[3] There are also earlier empirical studies that have found a positive relationship between economies of scale and the Grubel-Lloyd index of intra-industry trade; see Greenaway and Torstensson (1997) for a recent survey on the intra-industry trade literature.

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 γ_i is distributed according to the density function $\phi(.)$ with support $[0, \gamma_{n_a}]$, 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 make sure that some firms trade and other do not, γ_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, π_i, is necessarily non-negative.[4]

Since there are two types of firms: trading and non-trading firms, consider first the non-trading firms. Each of them maximizes $\pi = p_d x_d - (\alpha + \beta x_d) w$ with respect to x_d. A non-trading firm follows therefore the standard Lerner pricing rule,

$$p_d = w\beta(1 - \frac{1}{\varepsilon})^{-1}, \tag{2}$$

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 $\varepsilon = 1/1 - \theta$ 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

$$x_d = \frac{\alpha\theta}{\beta(1-\theta)}. \tag{3}$$

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[4] Montagna (1998) generates differences in profits by introducing heterogeneous marginal costs of production. Profitability differences among firms are found empirically in 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.

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 $L = n_a (\alpha + \beta x_d)$. Hence, the autarkic number of goods is $n_a = L(1-\theta)/\alpha$.

Consider now a trading firm. Firm i supplies x_{id} units at home and sells x_{if} units abroad, so that firm i's total labor requirement is $l_i = \alpha + \beta x_{id} + \gamma_i + \beta \tau x_{if}$, and its profit is

$$\pi_i = p_{id} x_{id} + p_{if} x_{if} - (\alpha + \beta x_{id} + \gamma_i + \beta \tau x_{if})w. \tag{4}$$

Maximizing (4) with respect to x_{id} and x_{if}, it is easy to establish that p_{id} also satisfies (2) and that $p_f = \tau p_d$ 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 given by (3). Second, utility maximization requires that, in equilibrium, individual consumption satisfies $c_d^{\theta-1}/c_f^{\theta-1} = 1/\tau$ implying that $x_f = \tau^{\theta/\theta-1} x_d$.

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

$$\tilde{\gamma} = \alpha \tau^{\theta/(\theta-1)}. \tag{5}$$

This is an important relationship for two reasons. First, $\gamma_i \leq \tilde{\gamma}$ 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 this model, an exporting firm exploits economies of scale at least

as well as a non-trading firm.[5] Second, any change in transport cost or in the fixed cost of production affects $\tilde{\gamma}$ and thus the number of traded goods $n_a \Phi(\tilde{\gamma})$. The fact that the number of traded goods increases with lower barriers to trade is not surprising. Simply, since the direct cost of exporting decreases, the marginal non-trading firm finds profitable to export its product.[6] 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 decreases the total number of products available to consumers since more resources are devoted to fixed costs. Given the utility function, each consumer increases its demand for every surviving product, including foreign ones. Since prices do not depend on α, the firm just indifferent between trading and non-trading before the increase in α, earns now a profit. This induces some firms with a higher fixed cost of exporting to engage in trade. In other words, the relative cost of exporting declines with α and the additional resources required by a higher α come only from non-trading firms.

This result implies that the significant changes in technologies that have occurred over the post-WWII period aimed at exploiting scale and scope economies may induce higher volumes of trade. We now derive the precise relationship between α and the volume of trade as well as with the share of trade in total production.

3. Technological Changes and Volume of Trade

We define the volume of trade as the volume of exports net of the units devoted to transportation and thus as

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[5] This contrasts with the standard model in which firms exploit economies of scale equally well in autarky and in free trade.
[6] See Schmitt and Yu (2001) for the implications of this result.

$$T = n_a \Phi(\tilde{\gamma}; \alpha) x_f, \tag{6}$$

where $n_a \Phi(\tilde{\gamma}; \alpha)$ is the number of traded goods that depends on the critical fixed cost of exporting which in turn depends on the level of the fixed cost of production. We model an increase in the degree of scale economies by an increase in α relative to the variable unit cost. Differentiating (6), the overall effects on export volume of a change in α are

$$\frac{dT}{T} = [\frac{\alpha}{n_a} \frac{dn_a}{d\alpha} + \frac{\alpha}{\Phi} \frac{d\Phi(\tilde{\gamma}; \alpha)}{d\alpha} + \frac{\alpha}{x_f} \frac{dx_f}{d\alpha}] \frac{d\alpha}{\alpha}.$$

The two first terms capture the effect of a change of α on the benchmark number of firms and on the distribution Φ, while the last term captures the effect on the firm export. Using (3) and (5), it is easy to show that the first term is equal to -1 and the last term is equal to 1. Hence,

$$\frac{dT}{T} = \frac{\alpha}{\Phi} (\phi \frac{d\tilde{\gamma}}{d\alpha} + \frac{\partial \Phi}{\partial \alpha}) \frac{d\alpha}{\alpha} > 0, \tag{7}$$

since an increase in α increases $\tilde{\gamma}$ and Φ (i.e., $\partial \Phi(\gamma, \alpha)/\partial \alpha > 0$). Thus, an increase in the fixed cost of production unambiguously increases the volume of trade.

We now show that an increase in α also increases the share of trade in total production. To do so, we must determine the effect of a change in α on production. This requires considering only the change in production that accompanies a change in total fixed costs of production and of export since total resources are necessarily devoted to cover either the fixed costs or else production (including transport costs). Hence,

$$\frac{dP}{d\alpha} = \frac{1}{\beta} \{\frac{d(n\alpha)}{d\alpha} + \frac{d}{d\alpha} [n_a \int_0^{\tilde{\gamma}} \gamma \phi(\gamma) d\gamma]\}, \tag{8}$$

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

$$L = n(\alpha + \beta x_d) + n_a(\int_0^{\tilde{\gamma}} \gamma\phi(\gamma)d\gamma + \Phi(\tilde{\gamma})\beta\tau x_f). \tag{9}$$

Using (9), (8) can be written as

$$\frac{dP}{d\alpha} = \frac{1}{\beta}\{(\theta-1)\frac{d}{d\alpha}[n_a\int_0^{\tilde{\gamma}} \gamma\phi(\gamma)d\gamma] - \theta\frac{d(\tilde{\gamma}n_a\Phi(\tilde{\gamma}))}{d\alpha} + \frac{d}{d\alpha}[n_a\int_0^{\tilde{\gamma}} \gamma\phi(\gamma)d\gamma]\} \tag{10}$$

$$= \frac{\theta}{\beta}\{\frac{d}{d\alpha}[n_a\int_0^{\tilde{\gamma}} \gamma\phi(\gamma)d\gamma] - \frac{d(\tilde{\gamma}n_a\Phi(\tilde{\gamma}))}{d\alpha}\}$$

$$= -(\frac{\theta}{\beta})\frac{d}{d\alpha}[n_a\int_0^{\tilde{\gamma}} \Phi(\gamma)d\gamma]$$

We cannot sign dP/dα with a general distribution function Φ. An increase in α 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 α. This reasoning is indeed correct for a uniform distribution function Φ.

If γ_i is uniformly distributed, $\Phi(\gamma) = \gamma/\gamma_{n_a}$ (where γ_{n_a} is the fixed export cost when all

firms are non-trading), so that $\int_0^{\tilde{\gamma}} \Phi(\gamma)d\gamma = \frac{\tilde{\gamma}^2}{2\gamma_{n_a}}$. Since $\tilde{\gamma} = \alpha\tau^{\theta/(\theta-1)}$ and $\alpha = L(1-\theta)/n_a$,

$$n_a\int_0^{\tilde{\gamma}} \Phi(\gamma)d\gamma = \frac{L^2(1-\theta)^2\tau^{2\theta/(\theta-1)}}{2n_a\gamma_{n_a}}. \tag{11}$$

Substituting (11) in (10), we get

$$\frac{dP}{d\alpha} = -(\frac{\theta L^2(1-\theta)^2\tau^{2\theta/(\theta-1)}}{2\beta})\frac{d}{d\alpha}(\frac{1}{n_a\gamma_{n_a}}) < 0,$$

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since n_a and γ_{n_a} are decreasing in α. Hence, everything else being equal, an increase in the fixed cost α reduces total production.

The implications of the model are thus clear: by increasing industry trade and by decreasing total output, an increase in the degree of economies of scale of production also contributes to the observed rise in the share of trade in total output. Equivalently, the share of intra-industry trade with respect to output is higher is sectors with higher degrees of scale economies.

4. Conclusion

In this paper, we have shown that, unlike in the standard model of intra-industry trade, the total volume of intra-industry trade and the share of trade in total output increase with the degree of economies of scale when one allows for firms' heterogeneity with respect to export markets and, in particular, for products to be non-traded. Harrigan (1994)'s findings that the volume of trade tends to be higher in sectors with larger scale economies constitute a direct confirmation of the relevance of the main result of this note.

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