



# research paper series

Internationalisation of Economic Policy Programme

Research Paper 2001/10

## Horizontal Intra-Industry Trade and the Growth of International Trade

*By N. Schmitt and Z. Yu*

The Centre acknowledges financial support from The Leverhulme Trust  
under Programme Grant F114/BF



**Leverhulme Centre**  
for Research on Globalisation and Economic Policy

**The Authors**

Nicolas Schmitt is Professor of Economics in the Department of Economics, Simon Fraser University and Zhihao Yu is Lecturer in the School of Economics, University of Nottingham.

**Acknowledgements**

Financial support from The Leverhulme Trust (Programme Grant F114/BF) is gratefully acknowledged.

---

# **Horizontal Intra-Industry Trade and the Growth of International Trade**

by

**N. Schmitt and Z. Yu**

## **Abstract**

We develop a model of monopolistic competition with traded and non-traded goods to explain the significant gap between the growth rates of trade and of output. It is shown that in a model with both traded and non-traded goods, the effect of trade liberalization on the change in the share of export in total output almost doubles compared to the standard model as some non-traded goods become traded when the cost of trade decreases.

## **Outline**

1. Introduction
2. The Model
3. Standard Results without Non-Traded Goods
4. Intra-Industry Trade with Non-Traded Goods
5. Economies of Scale and Non-Traded Goods
6. Conclusion

## Non-Technical Summary

The main question investigated in this chapter is whether a model of intra-industry trade with horizontal differentiation is able to explain the significant gap between the growth rates of trade and of output. We argue that it does, provided that the standard model of intra-industry trade (i.e., the Dixit-Stiglitz-Krugman model) includes non-traded products.

It is well known that the post-World War II period is characterized by a significantly higher growth rate in world manufactured trade than in world output. Roughly, world manufactured trade has grown on average by about 3% per year faster than GDP since 1950 (Harris, 1993; Rose, 1991). Recent years have not changed this picture. The World Trade Organization reported recently that developing countries' merchandise exports expanded by 8.5% in 1999, twice as fast as the global average and more than seven times the growth rate of world commodity output (WTO, 2000). At the same time, the share of intra-industry trade has increased significantly over the post-WWII period and it represents today a significant proportion of overall trade.

There is no well-accepted model explaining this gap in the growth rates (see for instance Krugman, 1995). Rose (1991) investigates empirically the role of lower barriers to trade (tariff and transport cost), the relative decline in the price of traded goods with respect to non-traded goods, as well as the role of the growth of international reserves and real income. Although lower tariffs do contribute to explain the growth of international trade, he finds no satisfying economic explanation that can capture most of the growth in trade. Ishii and Yi (1997) and Hummels, Ishii and Yi (1999) develop models of vertical specialization in production. The gap is then explained by the fact that countries specialize more and more in intermediate inputs generating extensive trade since products cross borders repeatedly as intermediate inputs and then as components within increasingly more finished products. This is an interesting and important avenue of research since a large, but apparently declining (see Ishii and Yi, 1997), share of international trade is in intermediate inputs. However, from their own account, vertical specialization explains at best 21% of total exports in 1990 for 10 OECD countries (representing 60% of world trade).

In this chapter, we want to argue that there is another, much simpler, channel through which the gap between growth in trade and in output can be explained: non-traded horizontally differentiated products are becoming traded as barriers to trade decrease.

This switch from non-traded to traded goods is consistent with Bernard and Jensen (1998) who investigate the US export boom between 1987 and 1992 at the firm level. Decomposing exports into a growth effect (i.e., exports rise proportionally to the increase in the firms' overall shipment) and into an export intensity effect (indicating a relative increase in export with respect to firms' overall shipment), the

authors find that 63% of the change in US exports between 1987 and 1992 is due to the change in the intensity effect alone. A further decomposition of this effect is particularly interesting since it is split equally between firms which were exporting both in 1987 and in 1992 but which are simply exporting now a larger fraction of their overall production, and the effect due to firms which were *not* exporting in 1987 but which are exporting in 1992. This last finding is important because it indicates that a significant number of firms with non-traded goods in 1987 are trading these products in 1992. It is this effect of non-traded products becoming traded that we wish to capture.

Ishii and Yi (1997) argue that there is no intra-industry model explaining how trade could grow at such a faster rate than production. Specifically, they argue that models such as Krugman (1980) are able to explain level effects but not *changes* effects. However none of the standard models of intra-industry trade used in the literature includes non-traded goods. We show that the traditional Dixit-Stiglitz-Krugman model of intra-industry trade can indeed take into account non-traded goods and help explaining these gaps in growth rates.

Specifically, we find that in a model with both traded and non-traded goods, the effect of trade liberalization on the change in the share of export in total output almost doubles compared to the standard model as some non-traded goods become traded when the cost of trade decreases. Furthermore, we also find that the change in the share of export is sensitive to higher degrees of scale economies.

## 1. Introduction

The main question investigated in this chapter is whether a model of intra-industry trade with horizontal differentiation is able to explain the significant gap between the growth rates of trade and of output. We argue that it does, provided that the standard model of intra-industry trade (i.e., the Dixit-Stiglitz-Krugman model) includes non-traded products.

It is well known that the post-World War II period is characterized by a significantly higher growth rate in world manufactured trade than in world output. Roughly, world manufactured trade has grown on average by about 3% per year faster than GDP since 1950 (Harris, 1993; Rose, 1991). Recent years have not changed this picture. The World Trade Organization reported recently that developing countries' merchandise exports expanded by 8.5% in 1999, twice as fast as the global average and more than seven times the growth rate of world commodity output (WTO, 2000). At the same time, the share of intra-industry trade has increased significantly over the post-WWII period and it represents today a significant proportion of overall trade.<sup>1</sup>

There is no well-accepted model explaining this gap in the growth rates (see for instance Krugman, 1995). Rose (1991) investigates empirically the role of lower barriers to trade (tariff and transport cost), the relative decline in the price of traded goods with respect to non-traded goods,<sup>2</sup> as well as the role of the growth of international reserves and real income. Although lower tariffs do contribute to explain the growth of international trade, he finds no satisfying economic explanation that can capture most of the growth in trade. Ishii and Yi (1997) and Hummels, Ishii and Yi (1999) develop models of vertical specialization in production. The gap is then explained by the fact that countries specialize more and more in intermediate inputs generating extensive trade since products cross borders repeatedly as intermediate inputs and then as components within increasingly more finished products. This is an interesting and important avenue of research since a large, but apparently declining (see Ishii and Yi, 1997), share of international trade is in intermediate inputs. However, from their own account, vertical specialization explains at best 21% of total exports in 1990 for 10 OECD countries (representing 60% of world trade).<sup>3</sup>

In this chapter, we want to argue that there is another, much simpler, channel through which the gap between growth in trade and in output can be explained: non-traded horizontally differentiated products are becoming traded as barriers to trade decrease.

This switch from non-traded to traded goods is consistent with Bernard and Jensen (1998) who investigate the US export boom between 1987 and 1992 at the firm level. Decomposing exports into a growth effect (i.e., exports rise proportionally to the increase in the firms' overall shipment) and into an export intensity effect (indicating a relative increase in export with respect to firms' overall shipment), the authors find that 63% of the change in US exports between 1987 and 1992 is due to the change in the intensity effect alone. A further decomposition of this effect is particularly interesting since it is split equally between firms which were exporting both in 1987 and in 1992 but which are simply exporting now a larger fraction of their overall production, and the effect due to firms which were *not* exporting in 1987 but which are exporting in 1992. This last finding is important because it indicates that a significant number of firms with non-traded goods in 1987 are trading these products in 1992.<sup>4</sup> It is this effect of non-traded products becoming traded that we wish to capture.<sup>5</sup>

Ishii and Yi (1997) argue that there is no intra-industry model explaining how trade could grow at such a faster rate than production. Specifically, they argue that models such as Krugman (1980) are able to explain level effects but not *changes* effects. However none of the standard models of intra-industry trade used in the literature includes non-traded goods. We show that the traditional Dixit-Stiglitz-Krugman model of intra-industry trade can indeed take into account non-traded goods and help explaining these gaps in growth rates.

Specifically, we find that in a model with both traded and non-traded goods, the effect of trade liberalization on the change in the share of export in total output almost doubles compared to the standard model as some non-traded goods become traded when the cost of trade decreases. Furthermore, we also find that the change in the share of export is sensitive to higher degrees of scale economies.

To our knowledge, Venables (1994) is the only existing paper that includes non-traded products in a standard model of intra-industry trade. However, his approach is different from

ours since non-traded goods emerge in his model from an asymmetry on the demand side (namely, preferences bias in favor of domestic products as with the Armington hypothesis) whereas non-traded goods in our model emerge from an asymmetry on the supply side (namely different fixed cost of exporting among firms). His concern is also different from ours as he wants to assess how the presence of non-traded goods affects the gains from economic integration.

The chapter is organized as follows. In the next Section, the basic model is developed. In Section 3, we briefly establish well-known results without non-traded goods and we discuss the implications of the standard model concerning the link between decreases in barriers to trade and the change in export shares. In Section 4, we introduce non-traded goods and we contrast the results with the outcome with traded goods only. In Section 5, we argue that, in our model, changes in technology also help explaining higher rates of change in trade and in the share of trade with respect to output. Section 6 concludes.

## 2. The Model

Consider the standard model of intra-industry trade with horizontal differentiation among final goods à la Krugman (see for instance, Krugman, 1980). There are two identical countries, Home (d) and Foreign (f). 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  $\mathbf{a}$  and a constant unit cost  $\mathbf{b}$ . To export, a firm incurs two additional costs: a fixed cost,  $\mathbf{g}_i \geq 0$ , and an international barrier to trade such that if  $\mathbf{t} = 1+t > 1$  units are shipped abroad only one unit arrives, where  $t$  represents the per-unit barrier to trade. Below we call it transport cost although  $t$  also includes tariff and non-tariff barriers. While transport cost is identical for all firms, the fixed cost of exporting has subscript  $i$  and is thus firm specific.

In terms of resources, if firm  $i$  supplies  $x_{id}$  units of its good to the domestic market and  $x_{if}$  units to the foreign market, the total labor requirement is

$$l_i = \mathbf{a} + \mathbf{b}x_{id} + \mathbf{g}_i + \mathbf{b}tx_{if}, \quad (1)$$

so that firm  $i$ 's profit is

$$\mathbf{p}_i = p_{id}x_{id} + p_{if}x_{if} - (\mathbf{a} + \mathbf{b}x_{id} + \mathbf{g}_i + \mathbf{b}tx_{if})w, \quad (2)$$



where  $w$  is the wage rate.

On the demand side, consumers in each country have identical preferences and the utility of each of these consumers is represented by

$$U = \sum_i c_{id}^q + \sum_j c_{jd}^q + \sum_l c_{lf}^q, \quad \mathbf{q} \in (0,1), \quad (3)$$

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. It is apparent that a consumer sees traded and non-traded goods as well as domestic and foreign goods as equally desirable.

Indeed the elasticity of substitution among these products is  $\mathbf{s} = \frac{1}{1-\mathbf{q}}$ .

The model is closed with the usual conditions that total consumption equal total production, that labor is fully employed and that no firm has an incentive to enter or to exit the industry.

We first establish the equilibrium without non-traded goods. Although these results are well known, they constitute our benchmark as far as the sensitivity of the model to trade liberalization is concerned since the equilibrium provides predictions concerning both the trade and the production response to trade liberalization.

### 3. Standard Results Without Non-Traded Goods

In the standard model, firms do not face a fixed export cost. Hence, in this Section, we impose  $\mathbf{g}_i = 0$ . Since the model boils down to the standard non-address model of intra-industry trade as developed by Krugman (1980), we do not dwell on the derivation of the equilibrium.

Maximizing (2) with respect to  $x_{id}$  and to  $x_{if}$ , firm  $i$ 's pricing rules follow standard Lerner conditions such that

$$p_{id} = w\mathbf{b}(1 - \frac{1}{\epsilon})^{-1} \quad \text{and} \quad p_{if} = w\mathbf{b}t(1 - \frac{1}{\epsilon})^{-1}, \quad (4)$$

where  $\epsilon$  is the price elasticity of demand. Maximizing (3) with respect to  $c_{id}$  and to  $c_{if}$ , it is easy to establish that  $\epsilon=1/1-\theta$  whether the product is domestic or foreign, at least when the number of products is large. Since all firms are identical in this symmetric two-country case (and thus

$p_{if}=p_{if}$ ), the no-entry/no-exit condition is the zero-profit condition. Setting (2) equal to zero and using the equilibrium prices just derived, the total production of firm  $i$ ,  $X$ , is

$$X = x_{id} + tx_{if} = \frac{aq}{b(1-q)}. \quad (5)$$

Utility maximization (and the equilibrium prices) requires that, in equilibrium,  $c_d^{q-1}/c_f^{q-1} = 1/t$ , so that, given  $x_f=Lc_f$  and  $x_d=Lc_d$  (supply equal demand conditions),

$$x_f = t^{1/q-1} x_d. \quad (6)$$

Using (5) and (6), it is then easy to establish that

$$x_d = \frac{aq}{b(1-q)(1+t^{q/(q-1)})}. \quad (7)$$

Finally, the full-employment condition requires that  $L = n(a + bX)$ , so that, in each country, the equilibrium number of products is

$$n = \frac{L(1-q)}{a}. \quad (8)$$

It is apparent that trade liberalization has no effect on the overall production of a firm and no effect on the overall number of products in each market since both (5) and (8) are independent of  $t$ . Simply, as  $\tau$  falls,  $x_f$  increases and  $x_d$  decreases by exactly the same magnitude.

This also tells us that the autarkic equilibrium in each country can easily be characterized since, in that case, the production of each firm is still given by (5), the number of products by (8) and the equilibrium price by  $p_d$  as given by (4).

Although we do not have a model of economic growth, we can investigate how exports respond to trade liberalization. Trade liberalization is understood as being a bilateral decrease in  $\tau$  and thus in  $t$ . The total volume of exports by one country, net of the units devoted to international transportation, is

$$T = nx_f = nt^{1/(q-1)} x_d. \quad (9)$$

Taking the derivative with respect to  $t$ , we obtain

$$\frac{dT}{T} = \left[ \frac{1}{1-q} - \left( \frac{q}{1-q} \right) \frac{t^{q/(q-1)}}{1+t^{q/(q-1)}} \right] \left( -\frac{dt}{t} \right). \quad (10)$$

As expected, a decrease in  $\tau$  increases trade since the expression in square brackets is necessarily positive. The first term is the substitution effect. A decrease in the relative price of the imported goods relative to the domestic goods increases the consumption of foreign relative to domestic goods. Since the same occurs in both countries then, everything else being equal, the net increase in the firm's overall production would be directly proportional to the elasticity of substitution. However, in equilibrium, the firm's overall production is independent of  $\tau$  (see (5)). The second term represents then the necessary correction affecting the level of trade making sure that firm's production remains constant.

In order to have a better idea of the implications of the standard model concerning the rate of change of the export share, we proceed as follows. First, observe that since total production is not affected by  $t$  in the standard model, then, necessarily, the rate of change of exports is the same as the rate of change of the export share (i.e.,  $\frac{dT}{T} = \frac{d(T/P)}{T/P}$ ). Second, since  $t=1+t$ , then

$\frac{dt}{t} = \frac{t}{1+t} \frac{dt}{t}$ . Hence, (10) can be rewritten as

$$\frac{dt}{t} = -\left[\frac{1}{1-q} - \left(\frac{q}{1-q}\right) \frac{t^{q/q-1}}{1+t^{q/q-1}}\right]^{-1} \left(\frac{t}{t-1}\right) \frac{d(T/P)}{T/P}. \quad (11)$$

The above relationship provides the rate of decrease in the barrier to trade  $t$  which, given the elasticity of substitution among goods and the initial level of the barrier to trade, is necessary to sustain a rate of increase of, say, 3% in the share of exports with respect to output. Table 1 provides these rates assuming  $\theta=0.5$  and thus with an elasticity of substitution equal to 2 as used in many CGE models (see for instance Mercenier and Schmitt, 1996).

**Table 1: Trade Liberalization in the standard model for  $\frac{d(T/P)}{T/P}=3\%$**

| $t$       | 100% | 90%   | 80%   | 70%   | 60%   | 50%   | 40%   | 30%   | 20%   | 10%   |
|-----------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| $-(dt/t)$ | 3.6% | 3.83% | 4.11% | 4.47% | 4.95% | 5.63% | 6.63% | 8.31% | 11.7% | 21.7% |

Table 1 has two features. First, the higher the initial level of trade barriers is, the lower is the required rate of trade liberalization sustaining a 3% increase in the share of exports. This is simply due to the fact that, when the initial level of trade barriers is high, the effect of trade

liberalization on the change in exports is necessarily large since export volumes are low. Second, Table 1 shows that an increase in the share of exports of 3% requires a high rate of trade liberalization. Rates are 'high' for the following reason. If one accepts that trade costs (including tariffs and non-tariff barriers) have decreased from by roughly 25% over a period of 35 years, as it is sometimes suggested (see Ishii and Yi, 1997), then the average rate of trade liberalization is less than 1% per year.<sup>6</sup> Table 1 shows that the standard model requires the rate of trade liberalization to be at least 3.6% per year. However, an unrealistic initial barrier to trade of 100% (i.e., for every two units shipped abroad, only one arrives) is required to obtain this lower bound. In the next Section, we develop a version of the model that generates significantly lower rates of trade liberalization.

#### 4. Intra-Industry Trade with Non-Traded Goods

The presence of non-traded products requires introducing an asymmetry between trading and non-trading firms. This asymmetry is introduced by imposing a fixed cost of exporting incurred by the firms engaged in trade. Of course, just a fixed cost is not enough to generate two types of firms since either this cost is low enough and every firm chooses to engage in trade, or it is high enough and none of them chooses to trade. We therefore assume that this fixed cost of exporting  $g_i$  is firm-specific and is distributed according to the density function  $f(\cdot)$  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  $\Phi(\cdot)$  to denote the cumulated density function. To make sure 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 is necessarily non-negative.<sup>1</sup>

Like with the standard model, firms segment the two markets (take separate decisions for each of them). Each trading firm maximizes (2) with respect to  $x_d$  and  $x_f$  while a non-trading firm maximizes

---

<sup>1</sup> Montagna (1998) generates differences in profits by introducing heterogeneous marginal costs of production. Also see a recent paper by Jean (2000). Empirically, profitability differences among firms are found in Mueller

$$\mathbf{p} = p_d x_d - (\mathbf{a} + \mathbf{b}x_d)w, \quad (12)$$

with respect to  $x_d$ . Following the same methodology as in the previous Section, any good produced for the domestic market is sold at price  $p_d = \mathbf{b}w/\mathbf{q}$  and, given  $\pi=0$ , each of the non-trading firms produces

$$x_d = \frac{\mathbf{a}\mathbf{q}}{\mathbf{b}(1-\mathbf{q})} \quad (13)$$

for the domestic market.

The above analysis implies that, in autarky and thus when all the firms are non-trading, the total number of goods produced in each country is determined by  $L = n_a(\mathbf{a} + \mathbf{b}x_d)$ . Hence, this autarkic number of goods,  $n_a$ , is given by (8).

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 demand and thus the total domestic production of each trading firm is also given by (13). It is now easy to derive the firm's behavior on the export market. Firms maximize (2) with respect to  $x_f$ . Like in the previous Section,  $p_f = \mathbf{b}w\mathbf{t}/\mathbf{q} = p_d\mathbf{t}$  and, given the equilibrium prices, consumer's utility maximization requires  $c_d^{q-1}/c_f^{q-1} = 1/\mathbf{t}$ . It follows that  $x_f = \mathbf{t}^{1/q-1}x_d$  (identical to (6)) since all consumers buying both types of goods consume  $x_k = Lc_k$  ( $k=d,f$ ) units. Hence, unlike with the standard formulation of the model, a change in  $\tau$  does not affect the production and the consumption of domestic products but only the level of trade (and the consumption of foreign products). This implies that an exporting firm produces necessarily a larger volume of output than a firm concentrating on its home market only and thus that total firm production depends on the level of the barrier to trade. Indeed,

$$\begin{aligned} X &= x_d + \mathbf{t}x_f \\ &= \frac{\mathbf{a}\mathbf{q}}{\mathbf{b}(1-\mathbf{q})}(1 + \mathbf{t}^{q/q-1}) \end{aligned}$$

---

(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.

We are now able to find the level of fixed export cost that just ensures zero profit on the export market. We denote this fixed cost by  $\tilde{g}$  and it is obtained by solving  $p_{if}x_{if} - (\tilde{g} + bt_{if})w = 0$ . Using the relevant price and (6), we get

$$\tilde{g} = at^{q/(q-1)}. \quad (14)$$

This is an important relationship for several reasons. First, it is easy to show that  $g_i \leq \tilde{g}$  corresponds to the condition that the 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.<sup>7</sup> 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 is decreasing, some non-trading firms find profitable to export their product. It is more surprising that the number of traded goods increases with the fixed cost. The easiest way to understand this is to realize that an increase in  $\alpha$  increases the cost of producing a good (whether or not it is traded) relative to the cost of exporting. Producing a non-traded good becomes then relatively more expensive relative to producing a trading good increasing thereby the share of traded goods in this market. Below, we investigate these two effects separately.

#### 4.1. Trade Liberalization with Non-Traded Goods

We first compute the rate of change in exports generated by trade liberalization. As before, we define the total volume of exports of the home country net of the units devoted to transportation. Recall however that the distribution of  $\gamma$  is defined with respect to the autarkic number of firms  $n_a$  so that the volume of exports is  $T = n_a\Phi(\tilde{g})x_f$ , where  $n_a\Phi(\tilde{g})$  represents the number of trading firms given the overall distribution of  $\gamma$ . Changes in the export volume as a result of a decrease in transport costs can be captured by

$$\frac{dT}{T} = \left[ \frac{t}{x_f} \frac{dx_f}{dt} + \frac{f(\tilde{g})}{\Phi(\tilde{g})/\tilde{g}} \frac{t}{\tilde{g}} \frac{d\tilde{g}}{dt} \right] \frac{dt}{t} \quad (15)$$

There are two effects which both contribute to increase the volume of exports. The first term is the change in export volume by the existing exporters. The second term is the change in the

number of exporters as a result of trade liberalization. A decrease in  $t$  increases profits from export and thereby, at the margin, the number of exporters.

Using (6) and (14),

$$\frac{dT}{T} = \left[ \frac{1}{1-q} + \frac{q}{1-q} \left( \frac{f(\tilde{g})}{\Phi(\tilde{g})/\tilde{g}} \right) \right] \left( -\frac{dt}{t} \right) \quad (16)$$

Comparing (16) with (10), the change in exports following trade liberalization is unambiguously greater than without non-traded goods. The interpretation of the two terms in the square brackets of (16) is straightforward. The first term is the same as in (10) and it represents the substitution effect. In this version of the model, there is no corrective effect like in (10) since total firm production is no longer constant. The second term represents then the impact of the new exporters on trade volume since some non-traded goods become traded as a result of trade liberalization. This effect has the same sign as the first one making the volume of trade more sensitive to trade liberalization than in the standard version of the model.<sup>8</sup>

#### 4.2. Share of Trade with Non-Traded Goods

We now want to determine how, in the presence of non-traded goods, trade liberalization affects the gap between trade and output, or, equivalently, how trade liberalization affects the share of trade in total output in order to compare it with the rate implied by the standard model. To do so, we need first to determine the relationship between production and trade liberalization.

In this model, trade liberalization has two opposite forces on production. Since some firms become exporting firms without changing their domestic production, overall production must increase. However this added production requires resources that can only come from non-trading firms exiting the market since resources are fully employed. This, in itself, must decrease production. The net change in production results from these two opposite forces.

To compute the net change in production, we take the following steps. First, observe that the production embodied in exports is  $P_x = tT = n_a \Phi(\tilde{g}) t x_f$ . This implies that a decrease in  $t$  leads to the following increase in production

$$dP_x = n_a t x_f d\Phi + n_a \Phi(\tilde{g}) d(t x_f).$$

The first term represents the change in production due to the change in the number of exporters while the second term represents the change in production of the existing exporters. In terms of resources, this represents

$$bdP_x + \tilde{g}n_a d\Phi,$$

that is, the variable cost associated with the added production and the additional fixed resources from the new exporters. Since these resources come from non-traded firms exiting the market, the number of non-traded firms leaving the market is equal to

$$dn_{nt} = \frac{bdP_x + \tilde{g}n_a d\Phi}{a + bx_d}.$$

The net change in production following trade liberalization must then be equal to

$$\begin{aligned} dP &= dP_x - x_d dn_{nt} \\ &= \frac{1}{a + bx_d} [an_a \Phi d(tx_f) + an_a tx_f d\Phi - x_d \tilde{g}n_a d\Phi] \end{aligned}$$

Using the relationship between  $x_d$  and  $x_f$  as well as (14), the last two terms cancel out and we are left with

$$\begin{aligned} \frac{dP}{dt} &= \frac{an_a \Phi d(tx_f)}{a + bx_d} \\ &= -qn_a \Phi(\tilde{g})x_f \\ &= -qT \end{aligned} \tag{17}$$

Hence, a decrease in  $t$  unambiguously increases overall production.

We can now determine the relationship between trade liberalization and the change in the share of exports. To do so, we assume that  $g_i$  is uniformly distributed and, therefore, that

$$\frac{f(\tilde{g})}{\Phi(\tilde{g})/\tilde{g}} = 1.$$

Using (16) and (17), trade liberalization as a function of the change of the export share can be found to be equal to



$$\begin{aligned} \frac{dt}{t} &= \left[ \frac{t}{T} \frac{dT}{dt} - \frac{t}{P} \frac{dP}{dt} \right]^{-1} \left( \frac{t}{t-1} \right) \frac{d(T/P)}{T/P} \\ &= \left[ \frac{q+1}{q-1} + q \frac{tT}{P} \right]^{-1} \left( \frac{t}{t-1} \right) \frac{d(T/P)}{T/P} \end{aligned} \quad (18)$$

The first term in square brackets represents the change in trade without the resource constraint, while the second term represents the change in production. Not surprisingly this last term is proportional to the share of trade in total production. Of course, these two terms have opposite signs. Assuming, like in the previous Section, that  $\theta=0.5$  and  $\frac{d(T/P)}{T/P} = 3\%$ , Table 2 shows that the rates of trade liberalization implied by the model with non-traded goods.

**Table 2: Trade Liberalization and Non-Traded Goods for  $\frac{d(T/P)}{T/P} = 3\%$**

| $T$       | 100% | 90%  | 80%  | 70%  | 60%  | 50%  | 40%  | 30%  | 20%  | 10% |
|-----------|------|------|------|------|------|------|------|------|------|-----|
| $-(dt/t)$ | 2.1% | 2.2% | 2.3% | 2.5% | 2.7% | 3.1% | 3.6% | 4.4% | 6.1% | 11% |

Comparing Tables 1 and 2, the implied rates of trade liberalization sustaining an increase in the share of exports of 3% are much lower (almost by half) in the present version of the model than in the standard model and are thus more realistic despite the increase in production that trade liberalization generates.

However, the implied rate of trade liberalization is still relatively high. We now discuss the second feature of the model with non-traded goods that may also contribute to boost trade relative to production.

### 5. Economies of Scale and Non-Traded Goods

As we noticed with (14), an increase in the fixed cost of production  $\mathbf{a}$  increases the number of traded goods (i.e.,  $d\tilde{g}/d\mathbf{a} > 0$ ). In other words, a change in technology making the fixed cost of production larger relative to the unit cost of production and to the cost of exporting may be an added effect contributing to an increase in the volume of trade.

This is quite different from the standard model since, as can be seen from (9), an increase in the fixed costs of production does not change the total volume of trade. Simply, an increase in  $\mathbf{a}$  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.

In the presence of non-traded goods, a general increase (i.e., all the firms in both countries) in  $\mathbf{a}$  raises the output and export of each trading firm, and it increases the number of exporting firms as the relative cost of exporting falls. The intuition is the following. An increase in  $\mathbf{a}$  implies that more resources cannot be devoted to direct production of goods. This leads to a decrease in the number of available variants and, because of the utility function, each consumer reacts by increasing the volume of consumption of each 'surviving' variant. This implies that the demand for foreign products increases and thus that the firms just indifferent between trading and not trading make now a profit (recall that prices are independent of  $\mathbf{a}$ ). Hence, more firms will want to become exporters establishing a link between the degree of scale economies and the share of trading firms in the total number of firms. By implication, the total volume of exports necessarily goes up with  $\mathbf{a}$  just like it does with trade liberalization.

Schmitt and Yu (2000) show precisely the effects of a change in  $\mathbf{a}$  on trade and on production. In particular, we show that an increase in  $\mathbf{a}$  raises the volume of trade and decreases production, at least with uniform distribution of  $\mathbf{g}$ . Hence, an increase in  $\mathbf{a}$  increases both the volume of trade and the share of trade in total output.

Although it is more difficult to compute a back-of-the-envelope rate of change in exports due to a change in fixed cost than it is with trade liberalization, 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 they have been significant, then this model predicts that they also have contributed to the increase in international trade. It is interesting to note that, although we are not aware of any direct evidence linking increases in economies to the growth rate of trade, Harrigan (1994) finds that the volume of trade is higher in sectors with larger scale economies. This is a direct implication of our model.

## 6. Conclusion

In a recent article, 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.<sup>9</sup> This chapter not only underlines the role of trade liberalization and lower transportation costs in an environment where firms are heterogeneous but also points out the role of technological changes particularly those leading to higher degrees of economies of scale.

Specifically, we have argued that the simultaneous presence of non-traded horizontally differentiated goods and heterogeneity among firms in their ability to export is helpful to make trade and export shares more sensitive to trade liberalization as well as to changes in technology than in the standard model of intra-industry trade. This proves helpful if one wants to use intra-industry trade models to explain the persistent and wide gap between growth of trade and of output during the post-war period. Although our analysis has been cast in the standard framework of consumer final products, it must be clear that the conclusions would not be altered had we considered traded and non-traded intermediate products à la Eicher (1982).

We could imagine additional features of the model boosting further the sensitivity of trade to decreases in barriers to trade. One feature would be to consider multi-product firms where, for each firm, some goods are traded and others are not. Another would be to have more than a single export market differentiated by fixed cost of exporting or by the cost of transportation (for instance because some markets are more distant from the home market than others). Trade liberalization then induces products to become traded simultaneously with respect to more than one market inducing thereby an even greater proportion of non-traded firms to exit the market in order to provide enough resources for these newly traded goods. In each of the above cases however the basic model remains the same and so is the message: the standard model of intra-industry trade in horizontally differentiated products can be amended to capture most, if not all, of the observed increase in the share of exports.

## References

- Baier, S. and J. Bergstrand (1999), 'The Growth of World Trade: Tariffs, Transport Costs and Income Similarity', *Journal of International Economics*, forthcoming (2001).
- Balassa, B., 'The Purchasing-Power Parity Doctrine', *Journal of Political Economy*, (1964) 584-96.
- Bernard, A.; Eaton, J.; Jensen, J and S. Kortum, 'Plants and Productivity in International Trade', manuscript, Boston University, (2000).
- Bernard, A.B. and J.B. Jensen, 'Understanding the U.S. Export Boom', NBER Working Papers 6438, March (1998).
- Brühlhart, M. and R. Elliott, 'Adjustment to the European Single Market: Inferences from Intra-Industry Trade Patterns', CREDIT Research Paper 96/15, September (1996).
- Ethier, W.J., 'National and International Returns to Scale in the Modern Theory of International Trade', *American Economic Review*, 72 (1982) 389-405.
- Fontagné, L.; Freudenberg, M. and N. Péridy, 'Trade Patterns Inside the Single Market', Document de travail no. 97-07, CEPII, (1997).
- Harrigan, James, 'Scale Economies and the Volume of Trade', *The Review of Economics and Statistics*, 76 (1994) 321-28.
- Harris, R.G., 'Globalization, Trade and Income', *Canadian Journal of Economics*, 26 (1993) 755-75.
- Hummels, D., 'Have International Transportation Costs Declined?', manuscript, University of Chicago, July (1999).
- Hummels, D.; J. Ishii and K.M. Yi, 'The Nature and Growth of Vertical Specialization in World Trade', manuscript, March (1999).
- Ishii, J. and K.-M. Yi, 'The Growth of World Trade', Research Paper 9718, Federal Reserve Bank of New York, May (1997).
- Jean, S. (2000), "International trade and firms' heterogeneity under monopolistic competition" CEPII, Working Paper No. 00-13.
- Krugman, P., 'Growing World Trade: Causes and Consequences', *Brookings Papers on Economic Activity*, 1 (1995) 327-77.
- Krugman, P., 'Scale Economies, Product Differentiation, and Pattern of Trade', *American Economic Review*, 70 (1980) 950-59.
- Mercenier, J. and N. Schmitt, 'On Sunk Costs and Trade Liberalization in Applied General Equilibrium', *International Economic Review*, 37 (1996) 553-71.
- Montagna, C. (1998) 'Efficiency Gaps, Love of Variety and International Trade', University of Dundee, Economics Discussion Paper No.90.
- Roberts, M.; Sullivan, T. and J. Tybout, 'What Makes Export Boom? Evidence from Plant-Level Panel Data', manuscript, December, (1995).
- Rose, A., 'Why has Trade Grown Faster than Income', *Canadian Journal of Economics*, 24 (1991) 417-27.

Schmitt, N. and Z. Yu, 'Economies of Scale and the Volume of Intra-Industry Trade', manuscript, December, (2000).

Venables, T., 'Integration and the Export Behaviour of Firms: Trade Costs, Trade Volumes and Welfare', *Weltwirtschaftliches Archiv*, (1994).

WTO, 'World Developments and World Trade in 1999', World Trade Organization, Press Release 175, April 6, (2000).

## Notes

---

<sup>1</sup> Concerning the EU, Fontagné, Freudenberg and Périody (1997) find that the share of intra-industry trade increased from about 55% in the early 1980s to 65% in 1994. Brülhart and Elliott (1996) report that the number of European industries (at five digit level) where significant intra-industry occurs increased from 365 in 1961 to 2203 in 1992.

<sup>2</sup> The argument is that the price of traded and non-traded goods is determined by the productivity in each sector and that productivity in the traded good sectors increases faster with real income (Balassa, 1964).

<sup>3</sup> This share may have increased to 30% in 1995.

<sup>4</sup> Note that it is quite possible that firms trading in both years increase their share of exports relative to shipment by selling in markets they were initially not engaged in. Hence, products of these firms may simply become traded with respect to specific markets (for instance, markets further away from the home market). See Hummels (1999) for evidence that transportation costs associated with increased distance have declined.

<sup>5</sup> See also Roberts, Sullivan and Tybout (1995) for an empirical analysis of the importance of heterogeneity among firms and export boom mainly explained by non-exporters re-tooling to sell in foreign markets, as well as Bernard et al. (2000) for a detailed analysis of plant-level heterogeneity in exporting.

<sup>6</sup> This is obtained by solving  $(1 + dt/t)^{35} = 0.75$ .

<sup>7</sup> This contrasts with the standard model in which firms exploit economies of scale equally well in autarky and in free trade.

<sup>8</sup> Note that Venables (1994) also finds that the volume of trade is more sensitive to trade liberalization with non-traded goods than with traded goods only.

<sup>9</sup> See Baier and Bergstrand (1999) for a recent empirical attempt to disentangle some of these forces.