# Factor Endowments, Country Size, and Trade Liberalisation: The Effects on Structure of Trade and Industry[*]

Thomas Mathä

University of East Anglia
School of Economic and Social Studies
Norwich NR4 7TJ
England
Tel.: ++44 1603 593716
e-mail: T.Mathae@uea.ac.uk

and

Stockholm School of Economics
European Institute of Japanese Studies
Box 6501
113 83 Stockholm
Sweden
Tel.: ++46 8 7369367
e-mail: japtm@hhs.se

*Working Paper Series in Economics and Finance No. 213*

*December 1997*

*Revised version: July 1998*

**Abstract:**

This paper analyses the effects of non-tariff barriers, in terms of both variable and fixed export costs, on the structure of trade and industry. We find that the relationship between fixed and variable trade costs affects industrial structure and determines whether international trade emerges. Such implications cannot be derived by considering variable trade costs alone. Given that trade emerges, only variable, but not fixed trade costs, influence factor price differentials, trade volumes and structure, and thus the share of intra-industry trade. It is also shown that country size differences affect the relationship between variable trade costs and trade structure.

*Keywords:* Economic Integration, Non-Tariff Barriers, Intra-& Inter-Industry Trade

*JEL Classification:* F12, F15

---

[*] I would like to thank Ari Kokko and Stephen Davies, and discussants of various workshops at the University of East Anglia, and the Stockholm School of Economics, where earlier versions of this paper were presented. Special thanks to Bruce Lyons and Michael Pfaffermayr for their help and insightful comments. Financial help from the DAAD and SI is gratefully acknowledged.

## Introduction:

New international trade models, which incorporate economies of scale and product differentiation into the framework of traditional trade theory, have proven to be very successful in that they provide a rationale for the seeming paradox that firstly, trade volumes are largest between similar countries and secondly, that the sectoral trade pattern is predominantly of intra- rather than inter-industry kind. These phenomena are inconsistent with the predictions of traditional trade theory, which is solely based on the notions of comparative advantage and factor abundance.

However, the international trade literature has not been as forthcoming with regard to trade barriers, such as transport costs. Reasons are partly pure negligence, and partly that introducing trade barriers ultimately means to give up the so '*highly desired*' result of factor price equalisation. Furthermore, few though there may have been, almost all the contributions focus on '*iceberg*' transport costs or '*ad valorem*' tariff barriers.

More recently, the attention shifted to non-tariff barriers as sources of impediments for trade liberalisation and economic integration.[1] These trade barriers are commonly modelled as an '*equivalence*' to ad valorem tariff barriers, despite exhibiting both variable and fixed trade costs components. Nevertheless, it has not been attempted to include both fixed and variable trade costs, in order to analyse how trade volumes and structure are affected, as yet.[2]

In this paper, a theoretical model is developed that introduces trade barriers in form of both fixed and variable trade costs. In doing so, I will develop a model in tradition of Krugman (1981), and Helpman & Krugman (1985). Due to the additional introduction of trade related fixed costs the equilibrium industry structure is affected. This is to say that the number of firms in the industry and the output per firm will be affected. Furthermore, the observed equilibrium '*type*' will change. While variable export costs merely determine the volume of international trade, the additional introduction of fixed export costs have the consequence that the equilibrium type might '*flip*'. For some level of the variable and fixed export costs, a marginal reduction in the fixed costs or in the variable export costs leads to an equilibrium change from autarky to a trade. Hence, the change in the number of firms or the change in output per firm will be a discontinuous relationship of trade liberalisation.

---

1 This is especially valid for the European integration process (e.g. Emerson et al., 1988).

2 Venables (1994) provides a welfare analysis of trade integration for identical countries, which includes both fixed and variable trade costs.

Furthermore, the paper analyses the effects that these different types of trade liberalisation have on the structure of international trade. Both intra- and inter-industry trade volumes are affected by the size of the variable costs. Furthermore, the fixed export costs do neither influence the volume nor structure of international trade.

Lastly, country size differences are introduced into the model in order to examine how the sectoral trade pattern is affected. The consequence is that the larger county may enjoy a '*false*' comparative advantage over the smaller country. This phenomenon is fairly well known in the literature. Nevertheless, to the best of my knowledge, no formal, theoretical model has been able derive this phenomenon, as yet.

## General framework:

There are two countries, each consisting of two industries respectively, one differentiated product industry and one homogenous product industry. The market structure in the former is monopolistic competition and in the latter perfect competition. Individuals in both countries are assumed to have identical consumer preferences. Furthermore, it is assumed that these preferences are of the Dixit and Stiglitz (1977) type. This is to say that the preferences can be modelled as part of a utility function with a constant elasticity of substitution, where consumers like variety as such. Accordingly, the more varieties are available in the economy the higher the utility level of each consumer, ceteris paribus. Economies of scale together with this assumption about individuals' utility function ensure that no more than one variety is produced by each firm in the economy. Moreover, this presentation of consumer preferences ensures that always equal expenditure shares are spent on the products from the different industries, whatever the income.

### Individuals' maximisation problem

$$U = c_1^{\chi} c_2^{1-\chi} \text{ with } c_1 = \left( \sum_{i=1}^{n^*} c_{1,i}^{\theta} \right)^{\frac{1}{\theta}} \qquad \text{s. t. budget constraint} \qquad (1)$$

$c_1$ and $c_2$ represent the consumption of the differentiated product and homogenous good respectively. $\theta$ is a measure of product differentiation. Given such representation of consumer preferences, the corresponding demand function has the convenient property that the elasticity of substitution is constant if the number of available varieties in the economy is

large enough.[3] It will be assumed that this is the case. Furthermore, it will always be the case that fixed shares of total expenditure are allocated to respective industries. The relative share depends on the magnitude of $\chi$. Following Helpman and Krugman (1985, p. 118) an individual's demand for a specific variety of a good produced by industry 1 can be written as:

$$x_{1,i} = \frac{p_{1,i}^{-\sigma}}{\sum_{i=1}^{n^*} p_{1,i}^{1-\sigma}} \chi e_i \text{ with } \sigma = \frac{1}{1-\theta}, \text{ and } \sigma > 1 \qquad (2a)$$

Hence, the demand for a specific variety depends on the price of the product divided by the industry specific price level, where $\sigma$ represents the elasticity of substitution between two product pairs in the differentiated product industry. $\chi$ is the share of expenditure spent on goods from the differentiated product industry, while $e_i$ represents the total expenditure by a representative individual. $n^*$ reflects the number of varieties potentially available. However, the number of varieties being actually produced in an economy will fall short of $n^*$ due to the fixed costs of production. Similarly, the demand for the homogenous good can be represented as a constant share of expenditure divided by its price.

$$x_2 = \frac{(1-\chi)e}{p_2} \qquad (2b)$$

**Technology**

Sector 1: $l_{1,i} = \alpha + \beta x_{1,i}$ (3a)

Sector 2: $l_{2,j} = \beta x_{2,j}$ (3b)

These functions may be best thought of in terms of labour hours. Thus, an individual firm has in total $l_{1,i}$ hours of labour available, where the number of hours $\alpha$ is spent irrespective of output. Similarly, $\beta$ can be thought of the marginal costs, in terms of personnel hours, needed in order to produce one unit of output. Given these input coefficients and the total amount of labour available for the individual firms, $x_{1,i}$ units of output can be produced. The production factors in the respective industries are totally specific to the industry. However, there are non-specific within industries. This is to say that the production factor in industry 1 is equally productive in producing any variety of the differentiated product. In other words, it is assumed that firms can costlessly differentiate products. Consequently, each variety will be produced by a different firm. Thus, each firm will be a

[3] The proof is given in Krugman (1981).

monopolist with respect to its own variety. Furthermore, it will be assumed that the foreign country has the same production technology available.

**Factor market**

Assuming full employment the factor constraints are as follows:

$$l_1 = \sum_{i=1}^{n_1} l_{1,i} = \psi \qquad (4a) \qquad l_2 = 1 - \psi \qquad (4b)$$

**Profit maximisation problem**

Industry 1

Trade in the homogenous good industry is assumed to be costless, while it is assumed that trade in the differentiated product industry exhibits trade barriers $TB_1$, which include fixed and variable cost components. In other words, $TB_1$ reflects the additionally required labour input when exporting.

$$TB_1 = t + \gamma x_{f,1} \qquad (5)$$

$\gamma x_{f,1}$ reflects the variable export costs, which depend on the export volume. $\gamma$ is a parameter for the distance, while $x_{f,1}$ denotes the exported quantity. More intuitively, think of $\gamma x_{f,1}$ as the costs, in terms of labour, when virtually carrying the goods in a rucksack over the border. Therefore, the total cost of exporting will depend on the wage rate.[4] Hence, there is no need to introduce a transport sector into model. Moreover, the domestic and export price elasticities of demand will be identical.[5] The desired effect is that the mark up over marginal cost is unaffected. The variable export costs drive a constant proportional wedge between the domestic and export price of domestically produced goods, which is a convenient property.

*t* can be seen to reflect the amount of fixed export costs, such as registration fees, market research or setting up a distribution network. Again the total amount of fixed costs will include the wage rate.

---

[4] In the trade literature, it has been most common to use '*iceberg*' transport costs. Iceberg transport costs are best thought of in terms goods that melt in transit. This is to say that only a fraction of the shipped goods reaches their destination. The variable export costs used in this model are of a different kind as the transport and production technology are allowed to be different from each other. With iceberg transport costs they are assumed to be identical.

[5] This is only valid if consumer preferences can be represented by CES utility function, as in the case of Dixit and Stiglitz (1977).

The profit function of a representative *domestic* firm in industry 1 can be rewritten as follows:[6]

$$\Rightarrow \pi_1 = p_{d,1}x_{d,1} + p_{f,1}x_{f,1} - \left(\alpha + \beta x_{d,1} + t + (\beta + \gamma)x_{f,1}\right)w_1 \qquad (6)$$

where the subscript *d* denotes domestic prices and output, while subscript *f* refers to prices charged in the foreign country, and output sold in the foreign country.[7] $p_{d,1}x_{d,1}$ is the domestic revenue, whereas $p_{f,1}x_{f,1}$ represents the revenue generated in the export market at export prices. $\left(\alpha + \beta x_{d,1}\right)w_1$ is the production cost of the domestically sold goods in terms of nominal costs. Finally, $(t + (\beta + \gamma)x_{f,1})w_1$ is the production cost, in nominal terms, of the amount of goods being exported, which includes variable and fixed export cost.[8]

Modelling trade barriers in this particular way means that the costs of exporting have to be borne by the producer of the good. Products to be exported have higher marginal costs and exhibit a fixed trade cost component. Due to the assumptions of costless product differentiation and identical input requirements, all firms in industry 1 will price at the same level. This means that all domestically produced and all imported varieties will be consumed in equal quantities respectively.

It follows from (2a) that the demand of a representative home country national for a domestically produced variety can be presented as follows:

$$x_{d,1} = \frac{p_{d,1}^{-\sigma}}{np_{d,1}^{1-\sigma} + NP_{f,1}^{1-\sigma}}\chi e \text{ with } \sigma = \left(\frac{1}{1-\theta}\right) \qquad (7a)$$

The notation used throughout this paper will be such that lower and upper case characters will denote home country and the foreign country respectively. Thus, home country consumers can consume *n* domestic and *N* foreign varieties. Similarly, the demand for an imported variety from the home country is given by:

$$x_{f,1} = \frac{p_{f,1}^{-\sigma}}{np_{f,1}^{1-\sigma} + NP_{d,1}^{1-\sigma}}\chi E \qquad (7b)$$

Profit maximisation with respect to $x_{d,1}$ and $x_{f,1}$ yield the following pricing conditions for respective countries and industries:

---

6 Hereafter, the indices referring to individual firms in industry 1 will be omitted for convenience, as they are identical due to the symmetry assumption.

7 For the wage rate, this subscript can be omitted as wages are always domestic wages.

8 The production fixed cost $\alpha$ has to be incurred only once.

$$p_{d,1} = \beta w_1 \theta^{-1} \qquad P_{d,1} = \beta W_1 \theta^{-1} \tag{8a}$$

$$p_{f,1} = (\beta + \gamma) w_1 \theta^{-1} \qquad P_{f,1} = (\beta + \gamma) W_1 \theta^{-1} \tag{8b}$$

The mark up over marginal cost is constant, equals $\theta^{-1} = \frac{\sigma}{\sigma - 1}$, and is identical for both domestic and exported varieties. Hence, a relationship between the domestic price and the export price for any variety produced in the home country can be derived. Please note that the respective pricing conditions are identical for foreign country firms, which export to the home country.

$$\frac{p_{d,1}}{p_{f,1}} = \frac{P_{d,1}}{P_{f,1}} = \frac{\beta}{\beta + \gamma} \tag{9}$$

Knowing all relevant pricing conditions in respective countries, a relationship between countries' domestic price and their respective equilibrium wage rate can be derived. This extends to export prices.

$$\Rightarrow \frac{p_{d,1}}{P_{d,1}} = \frac{p_{f,1}}{P_{f,1}} = \frac{w_1}{W_1} \tag{10}$$

Industry 2

In the homogenous product sector, prices equal marginal costs. The pricing conditions for domestically consumed and exported goods shown below:

$$p_{d,2} = p_{f,2} = \beta w_2 \qquad P_{d,2} = P_{f,2} = \beta W_2 \tag{11}$$

It follows that prices and wages in the homogenous product industry will be the same in both countries. Furthermore, it will be assumed that trade in the homogenous good sector is costless. The introduction of trade barriers into the homogenous good sector, would lead to non-tradability of the good, as the price charged in respective foreign markets would be higher than the price in respective domestic markets. As the good is homogenous, and as perfect competition is the underlying market structure, a higher price could not generate any demand.

**Demand functions**

The demand for domestic goods depends on both the price of domestic goods and on that of foreign goods. Without variable export costs, the assumption of identical production techniques would assure identical pricing. Thus, the individuals in the home country would

consume equal quantities of domestically and foreign produced varieties. Consumption will change in favour of domestically produced goods if foreign varieties are more expensive. Furthermore, consumption depends on the share $\chi$ in expenditure *e* that is allocated to the differentiated product industry. Substitution of (9) and (10) into (7a) leads to the following expression:

$$\Leftrightarrow x_{d,1} = \frac{p_{d,1}^{-1}}{n + N\left(\frac{\beta+\gamma}{\beta}\right)^{1-\sigma}\left(\frac{W_1}{w_1}\right)^{1-\sigma}}\chi e \tag{12}$$

Similarly, we can derive the demand for the exported varieties, in substituting (9) and (10) into (7b):

$$\Leftrightarrow x_{f,1} = \frac{\left(\frac{\beta+\gamma}{\beta}\right)^{-\sigma}\left(\frac{w_1}{W_1}\right)^{-\sigma}P_{d,1}^{-1}}{n\left(\frac{\beta+\gamma}{\beta}\right)^{1-\sigma}\left(\frac{w_1}{W_1}\right)^{1-\sigma} + N}\chi E \tag{13}$$

This expression represents the exported quantity of a representative home country firm. This exercise can now be repeated for the foreign country. Knowing all the relevant demand functions, we can derive a relationship between them. Subsequently, this allows us to calculate the profit function for a representative firm in both countries. The following two equations show the existing relationships between the demand for exported varieties from the home (foreign) country and demand for domestic varieties in the foreign ( home) country.

$$\Rightarrow x_{f,1} = \left(\frac{\beta+\gamma}{\beta}\right)^{-\sigma}\left(\frac{w_1}{W_1}\right)^{-\sigma}X_{d,1} \tag{16a}$$

$$\Rightarrow X_{f,1} = \left(\frac{\beta+\gamma}{\beta}\right)^{-\sigma}\left(\frac{W_1}{w_1}\right)^{-\sigma}x_{d,1} \tag{16b}$$

Together with (9), we can substitute (16a) into the profit function (6). Furthermore, denoting $\tau = \left(\frac{\beta+\gamma}{\beta}\right)^{1-\sigma}$ and $\delta = \left(\frac{w_1}{W_1}\right)^{-\sigma}$ yields the result of:

$$\pi = (1-\theta)p_{d,1}\left[x_{d,1} + \tau\delta X_{d,1}\right] - \frac{\theta p_{d,1}}{\beta}(\alpha + t) \tag{17a}$$

The profit function of a representative foreign firm, which is given below, is similar to the one above:

$$\Pi = (1-\theta) P_{d,1}\left[X_{d,1} + \tau\delta^{-1} x_{d,1}\right] - \frac{\theta P_{d,1}}{\beta}(\alpha + t) \qquad (17b)$$

Knowing that free entry assures zero profits in equilibrium, we can derive a relationship between a home country firm's domestic output and foreign country firm's domestic output.

$$\Rightarrow \frac{x_{d,1}}{X_{d,1}} = \frac{1-\tau\delta}{1-\frac{\tau}{\delta}} \qquad (18)$$

This relationship can be substituted back into the profit function, which yields the following final expression. In its current form, this expression represents a home country firm's domestic output.

$$\Rightarrow x_{d,1} = (\sigma - 1)\frac{\alpha + t}{\beta}\frac{1-\tau\delta}{1-\tau^2} \qquad (19)$$

However, before turning to the discussion of the industry structure, $\tau$ deserves more attention. For $0 \le \sigma \le 1$, $\tau$ will be a normal measure of variable export costs, while for $1 \le \sigma \le \infty$, $\tau$ will be an inverse measure. As mentioned earlier, the restriction of $\sigma \ge 1$ is a necessary condition, as marginal revenue would otherwise become negative. Hence, $\tau$ will be an inverse measure of variable export costs for all possible ranges of the elasticity of substitution. Accordingly, the free trading equilibrium is represented by $\tau = 1$.

## The case of identical countries

So far, we have derived the results for the general case, i.e. the factor prices were not necessarily equalised internationally.[9] We start examining the industrial structure and how it is affected by economic integration, in constructing the simplest of all scenarios.[10] This is to say that the two countries are assumed to completely identical. It follows immediately that both countries pay the same wage rate in the differentiated product sector. Subsequently, all previous equations simplify to: $\delta = \left(\frac{w_1}{W_1}\right)^{-\sigma} = 1$. Thus, the price and output of domestic firms are identical to those of foreign firms.

**Equilibrium selection (export vs. autarky)**

[9] Due to sector specificity of the production factors, it will be rather the exception than the rule that factor prices are equalised nationally. Hence, we will hereafter refer to factor price equalisation as being the case if countries' factor prices in the respective sectors are equalised.

[10] Henceforth, we will use the trade liberalisation and economic integration as synonyms.

Rearranging (19) yields a relationship that determines whether, at given trade barriers, the prevailing equilibrium will be a trading or non-trading equilibrium.

$$\Rightarrow \alpha + t \leq \frac{1}{\sigma - 1}(1+\tau)\beta x_{d,1} \qquad (20a)$$

Exporting is generally only a feasible option, if it is profitable for firms. If firms can regain the fixed costs $\alpha + t$, that they have to incur, trade will be feasible. Hence, for some level of $\alpha + t$, a marginal reduction in *t* will change the equilibrium outcome from autarky to trade. The reason is that firms are not necessarily able to recoup both the production and fixed trade costs, despite their ability to increase the prices proportionately with higher variable export costs. This effect is related to the restriction of $\sigma \geq 1$ on the elasticity of substitution, and thus the price elasticity of demand. As mentioned earlier, the price elasticity of demand has to exceed unity otherwise marginal revenue would be negative. Thus, the price elasticity of demand is constant and elastic by assumption. This means that, for a given rise in variable export costs, the magnitude of the proportional increase in the export price will not be sufficient to offset the reduction in demand for this particular variety. Hence, total revenue will decline for any given price-output combination if the price is increased. This means that firms will only export their products if the additional fixed costs *t* that have to be incurred can be recouped.

Therefore, the combination of fixed and variable export costs determines whether firms will export or not. In the limiting case there is obviously no difference due to the assumption of free entry, and thus zero profits in equilibrium.[11] However, there are differences to be noted in terms of the industrial structure.

If exporting is not a feasible option the firm will only have to incur the production fixed costs $\alpha$, but not the additional fixed costs *t*. Hence, (20a) can be split into two separate equations as shown below:

$$\Rightarrow \alpha \leq \frac{1}{\sigma - 1}\beta x_{d,1} \qquad (20b) \qquad\qquad \Rightarrow t \leq \frac{1}{\sigma - 1}\beta \tau x_{d,1} \qquad (20c)$$

A representative firm has only to recoup the fixed costs $\alpha$, in order to enter the market. If this is not possible, as the constant mark up over marginal costs is not high enough, the '*potential*' firm will not enter the industry. Hence, equation (20b) determines whether the

[11] We have nothing to say why one equilibrium type should be preferred to another one, as firms in both scenarios will end up with zero profits. However, one could imagine that, at a particular point, one firm starts offering marginally higher wages in order to enter the export market, with the effect that all other firms immediately follow suit.

industry is viable at all, if trade costs are at a prohibitive level. Equation (20c) determines how much output has to be exported in order to recoup the fixed export costs *t*, for a given size of variable export costs and constant mark up over marginal costs.

Finally, the export entry condition can be formalised by division of (20b) by (20c) which yields:

$$\Rightarrow t / \alpha \leq \tau \leq 1 \qquad (20d)$$

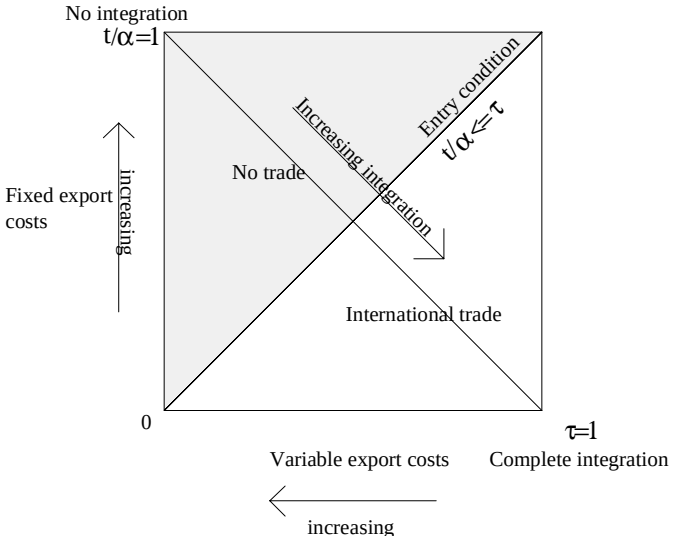
<u>*Proposition:*</u> *Exporting is feasible if* $t / \alpha$ *is smaller or equal* $\tau$*. Additionally, as* $0 \leq \tau \leq 1$*, this yields the restriction of* $t / \alpha \leq 1$.

For some level of *t* and $\tau$, both a marginal reduction in the fixed or variable export costs will change the equilibrium from autarky to trade. However, these two mechanisms of trade liberalisation have very different consequences. While reductions in both trade barriers have the tendency to facilitate the emergence of international trade, a reduction in *t* will additionally affect the equilibrium number of firms in the industry.

A different point is to be made if $t / \alpha \geq 1$. In this case exporting will never be feasible, no matter how large or small $\tau$ is. This is due to restriction of $0 \leq \tau \leq 1$. This highlights the fact that, in order to facilitate the emergence of international trade, trade liberalisation has to channel through reduction of fixed costs, and not just through a reduction of variable export costs or *ad valorem* tariff barriers. If the criterion $t / \alpha \leq 1$ is met the size of $\tau$ determines whether trade emerges or not. If integration is not very advanced with regard to the fixed export costs, i.e. $t / \alpha$ is close to 1, integration on the variable costs side will have to very advanced, i.e. $\tau$ is at least as large as $t / \alpha$, in order to generate international trade. Hence, in order to generate international trade flows, the degree of economic integration on the variable cost side needs to be very high if integration is low on the fixed costs side.

The opposite holds true, if the fixed export costs are low, but variable export costs are large. In this case, it will be likely that international trade emerges. If firms do not have to incur any fixed trade costs, and $\tau$ is close to zero, trade will still be feasible. The importance of increased economic integration, channelled through a reduction in fixed costs is shown in Figure 1 below:

Figure 1: Conditions for the emergence of international trade




**Equilibrium number of firms:**

The equilibrium number of firms in the industry is given by:

$$l_1 = \sum_{i=1}^{n_1} l_{1,i} = n(\alpha + \beta x_{d,1} + t + (\beta + \gamma) x_{f,1})$$

$$l_2 = \sum_{j=1}^{n_2} l_{2,j} = \textit{Not defined}$$

Substituting (20a) into this equation and using our knowledge about the relationship between $x_{d,1}$ and $X_{d,1}$ given by equation (18), the number of firms in the differentiated product industry in the home country emerges as:

$$\Rightarrow n = \frac{l_1}{\sigma(\alpha + t)} \qquad (21a)$$

The number of firms in the foreign country is derived similarly. The relationship shows that reductions of fixed export costs lead to an increase in the equilibrium number of firms. The equilibrium number of firms is independent of firms' output, and wage rate in the two countries. This may seem trivial though, as both these variables are endogenous. Hence, the number of firms sustainable in respective equilibrium is given by:

$$\Rightarrow n = \frac{l_1}{\sigma\alpha} \qquad \text{for} \quad \frac{t}{\alpha} \succ \tau$$

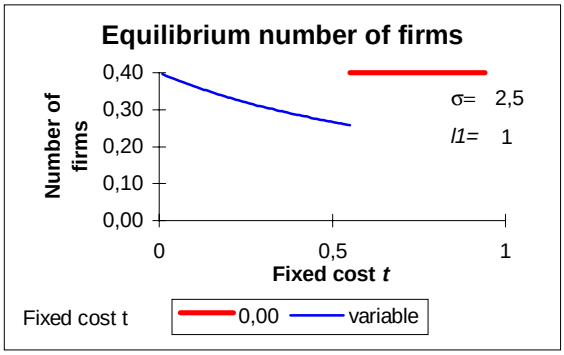
$$\Rightarrow n = \frac{l_1}{\sigma(\alpha + t)} \qquad \text{for} \quad \frac{t}{\alpha} \leq \tau$$

*Proposition:* *For some t and $\tau$, an marginal exogenous reduction of t will lead to a discontinuous reduction in the number of firms viable in industry 1.*

*Given that trade is feasible, a reduction in t will increase the number of firms viable in industry 1.*

In Figure 2 below, it is shown how a reduction in the fixed trade costs affects the number of firms viable in the industry. For a given level of fixed costs $\alpha$, the number of firms in the respective autarky and trading equilibrium is shown. For each level of $\alpha$ the number of firms in a trading equilibrium is smaller than the corresponding autarky situation. Given that trade is feasible, the larger the fixed trade costs are for any given size of $\alpha$, the larger the difference is between the number of firms in the respective autarky and trading equilibrium. Once trade is feasible, all firms in the differentiated product industry will turn exporters.[12]

Figure 2: Relationship between fixed export costs and the number of firms




Additionally, firms will be larger in size in a trading equilibrium, due to the higher total fixed costs. Correspondingly, the number of firms sustainable in the respective countries will be lower. Hence, consumers have less choice of domestically produced varieties. Nevertheless, the emergence of international trade, and thus foreign varieties, more than offsets this effect, as total number of varieties available will be larger than under autarky.[13]

**Firms' domestic, export and total revenue:**

Using the equations (19), (9), (16), and (18) leads to the following expressions for firms' domestic, export, and total revenue for the respective autarky and trading equilibrium:

[12] Unlike in the Venables (1994) model, it is not possible that small non-trading firms can survive.

[13] As the fixed export costs can maximally be as large as the production fixed costs, the maximal reduction in domestically produced variety is half of the variety available in autarky.

$$\Leftrightarrow p_{d,1}x_{d,1} = \sigma\alpha w_1 \qquad \text{for} \qquad \Rightarrow \frac{t}{\alpha} \succ \tau$$

$$\Rightarrow p_{f,1}x_{f,1} = 0 \qquad \text{for} \qquad \Rightarrow \frac{t}{\alpha} \succ \tau$$

$$\Leftrightarrow p_{d,1}x_{d,1} = \sigma(\alpha + t)\frac{1}{1+\tau} w_1 \qquad \text{for} \qquad \Rightarrow \frac{t}{\alpha} \leq \tau \qquad (21a)$$

$$\Rightarrow p_{f,1}x_{f,1} = \sigma(\alpha + t)\frac{\tau}{1+\tau} w_1 \qquad \text{for} \qquad \Rightarrow \frac{t}{\alpha} \leq \tau \qquad (21b)$$

$$\Rightarrow p_{d,1}x_{d,1} + p_{f,1}x_{f,1} = \sigma(\alpha + t)w_1 \qquad \text{for} \qquad \Rightarrow \frac{t}{\alpha} \leq \tau \qquad (21c)$$

<u>*Propositions:*</u> *The higher the fixed export costs, and the lower $\tau$, i.e. the larger the variable export costs are, the larger the revenue in the domestic market*

*The larger the fixed export costs, and the smaller the variable export costs are, the larger the revenue generated in the export market.*

*The larger the fixed export costs are, the larger firms' total revenue will be. In the case of factor price equalisation, total revenue is independent of the variable export costs.*

Both the domestic and the export revenue are positively affected by increases in the elasticity of substitution between product pairs, and higher domestic wage rates. A reduction in fixed trade costs leads to a reduction in domestic revenue. This is intuitive, as less revenue needs to be generated by a firm in order to break even. As firms sell their respective varieties with a constant mark up over marginal costs, a smaller quantity is sufficient to recoup the fixed costs $\alpha + t$. Similarly, a larger elasticity of substitution $\sigma$ corresponds to a lower mark up over marginal costs. Therefore, firms' equilibrium revenue has to increase in order to break even.

When analysing how the inverse measure of economic integration $\tau$ influences domestic revenue, it seems strange at first sight that domestic revenue is influenced at all. Moreover, as $\tau$ increases, i.e. as variable trade costs decrease, domestic revenue will decrease. However, bearing in mind that economic integration is bilateral, it seems clear that, at a given price, a representative firm cannot sell as many goods in the domestic market as under autarky. The reason is that domestic varieties are now competing with foreign varieties. Hence, domestic revenue will decline, given that trade is feasible, and given that economic integration is further increased.

The difference between domestic and export revenue is though that the lower the variable trade costs are, the larger the export revenue will be. As countries are assumed to be identical, the size of the export revenue can maximally be a half of total revenue. In this case, the variable export costs are zero, i.e. $\tau = 1$. Furthermore, this is irrespective of the additional fixed costs *t*. Alternatively, if $\tau = 0$, firms would not serve the export market at all. However, the interesting result is that the larger the fixed export costs are, the larger the revenue in the export market is. At first, this seems counterintuitive. Nevertheless, this interesting result can be explained, when considering that, in a trading equilibrium, an increase in the export fixed costs has to result in larger export and total revenue in order to make exporting worthwhile.

Furthermore, this corresponds to the relationship between the size of the fixed export costs and the number of firms viable in the differentiated product industry. Given that trade is feasible, an increase in the fixed export costs leads to a reduction in the number of viable firms in the industry. Thus, their domestic, export and total revenue have to rise.

Firms' total revenue does not depend on variable export costs. This suggests that, when varying the size of the variable export costs, the revenue generated in the domestic market and the revenue generated in the foreign country change inversely proportionally. Total revenue will unambiguously be larger in a trading equilibrium than in autarky, as fixed trade costs have to be incurred.

**Firms' domestic, export and total output:**

$$\Leftrightarrow x_{d,1} = (\sigma - 1)\frac{\alpha}{\beta} \qquad \text{for} \qquad \Rightarrow \frac{t}{\alpha} \succ \tau$$

$$\Leftrightarrow x_{f,1} = 0 \qquad \text{for} \qquad \Rightarrow \frac{t}{\alpha} \succ \tau$$

$$\Leftrightarrow x_{d,1} = (\sigma - 1)\frac{\alpha + t}{\beta}\frac{1}{1+\tau} \qquad \text{for} \qquad \Rightarrow \frac{t}{\alpha} \leq \tau \qquad (23a)$$

$$\Leftrightarrow x_{f,1} = \frac{p_{d,1}}{p_{f,1}}\tau X_{d,1} = (\sigma - 1)\frac{\alpha + t}{\beta}\frac{\tau^{\frac{\sigma}{\sigma-1}}}{1+\tau} \qquad \text{for} \qquad \Rightarrow \frac{t}{\alpha} \leq \tau \qquad (23b)$$

$$\Leftrightarrow x_{d,1} + x_{f,1} = (\sigma - 1)\frac{\alpha + t}{\beta}\left(\frac{\tau^{\frac{\sigma}{\sigma-1}} + 1}{1+\tau}\right) \qquad \text{for} \qquad \Rightarrow \frac{t}{\alpha} \leq \tau \qquad (23c)$$

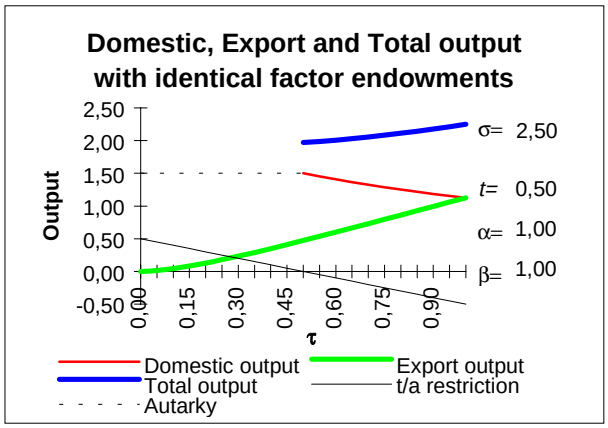
*Propositions:* *The larger the fixed export costs are, and the larger the variable export costs are, i.e. the smaller $\tau$, the larger domestic output will be.*

*The larger the fixed export costs and the smaller the variable export costs are, the larger the export output will be.*

If the economies of scale, as reflected by $(\alpha + t)/\beta$, or the degree of substitutability between product varieties, as measured by $\sigma$, are increased, the domestic and export output per firm will also increase. Furthermore, domestic output depends on $\tau$, as it was the case with domestic revenue. The interesting result is though that in autarky output per firm is independent of market size, as measured by the size of the factor endowments.[14]

Similarly to the export revenue, the export output function depends on $\tau/(1+\tau)$. Additionally, the expression $\tau^{\frac{\sigma}{\sigma-1}}$ enters the equation. This rather awkward form occurs because the export revenue function needs to be divided by the export price rather than the domestic price in order to derive the export output.

Figure 3: The relationship between variable export cost and output per firm




As depicted in Figure 3, total output will not be independent of the variable export costs, and will be twice as large as domestic output, if the variable export costs are zero.

## International trade structure

### Determination of the trade balance

The next steps are to calculate the income and expenditure of the home country. Knowing that they must be of equal size in equilibrium, we can derive the trade balance, which in turn determines the trade volumes and structure. The expenditure or consumption of the home country is given by:

[14] This result is identical to Krugman (1981), p. 963.

$$\Rightarrow p_2 c_2 + n p_{d,1} x_{d,1} + N P_{f,1} X_{f,1} = e$$

$$\Leftrightarrow p_2 c_2 + (n + \tau N) p_{d,1} x_{d,1} = e \qquad (26)$$

The factor income of the country can be calculated in using the full employment condition and the knowledge about the number of firms in equilibrium.

$$\Rightarrow w_1 l_1 + w_2 l_2 = w_1 \left[\alpha + t + \beta(1+\tau) x_{d,1}\right] n + w_2 \beta x_2$$

$$\Leftrightarrow w_1 l_1 + w_2 l_2 = p_{d,1} x_{d,1} (1+\tau) n + p_2 x_2 = e \qquad (27)$$

Trade balance

In equilibrium, factor income must equal expenditure. This gives us the following trade balance:

$$\Rightarrow p_2 c_2 + (n + \tau N) p_{d,1} x_{d,1} = e = p_{d,1} x_{d,1} (1+\tau) n + p_2 x_2$$

$$\Leftrightarrow p_{d,1} x_{d,1} \tau (n - N) + p_2 (x_2 - c_2) = 0 \qquad (28a)$$

Similarly, the trade balance for the foreign country is given by:

$$\Rightarrow P_2 C_2 + (N + \tau n) P_{d,1} X_{d,1} = e = P_{d,1} X_{d,1} (1+\tau) N + P_2 X_2$$

$$\Leftrightarrow p_{d,1} x_{d,1} \tau (N - n) + P_2 (X_2 - C_2) = 0 \qquad (28b)$$

As total trade flows have to be balanced, we know that the home country's net exports have to equal the foreign country's net imports in the respective industry. Thus, it is possible to generate the circumstances for which factor price equalisation will be possible.

$$\Leftrightarrow p_{d,1} x_{d,1} \tau (n - N) = -p_{d,1} x_{d,1} \tau (N - n) \qquad (29)$$

Inevitably, it follows that factor price equalisation is only possible if $n = N$. This means that, in equilibrium, both countries have to produce the same number of varieties of the differentiated product. Knowing the relationship between the number of firms sustainable in the differentiated product industry and the factor endowments, it follows that

$$l_1 = L_1 \qquad (30a)$$

Equalising both trade balances and using (30b) gives the result of:

$$l_2 = L_2 \qquad (30b)$$

Hence, the two countries have to completely identical in order to achieve international factor price equalisation in the respective industries.[15]

[15] See footnote 10.

Relative wages in equilibrium

It remains to determine the wage ratio between different industries. We know that the net exports from the home country in the homogenous good industry have to be equal to the net imports in the same sector in the foreign country:

$$\Rightarrow p_2(x_2 - c_2) = -P_2(X_2 - C_2)$$

$$\Leftrightarrow (1-\chi)(w_1 l_1 + W_1 L_1) - \chi(w_2 l_2 + W_2 L_2) = 0$$

Using (30b) and (30c) yields the following relationship:

$$\Leftrightarrow \frac{w_1}{w_2} = \frac{\chi l_2}{(1-\chi) l_1} \text{ with } 0 \leq \chi \leq 1 \qquad (30d)$$

The relative wage between the two industries is entirely determined by the relative share of the factor endowments and the share of aggregate consumption that is allocated to the respective industries. Furthermore, in a trading equilibrium, the relative wage is identical to the one in autarky. Lastly, the wage in one industry has to be chosen as the numéraire, and the model is closed.

International trade structure

It is interesting to know how differences in factor endowments and country sizes affect the sectoral pattern of trade, i.e. intra- and inter-industry trade, and the volume of trade. However, we know that the two countries have to be completely identical in order to generate factor price equalisation. Nevertheless, let us assume for the moment that factor price equalisation could be generated, even with positive variable transport costs. It will be assumed that $n \geq N$, as otherwise the trade balance is not represented correctly. The trade balance is formalised as:

$$\Rightarrow n\tau p_{d,1} x_{d,1} = p_{d,1} x_{d,1} \tau N + p_2(c_2 - x_2)$$

It follows that total trade, net trade, and intra-industry trade and their respective shares to total trade take the following forms:

Volume of total, net and intra-industry trade

$$\Rightarrow T_T = 2n\tau p_{d,1}x_{d,1} \qquad \Rightarrow T_T = 2\frac{\tau}{1+\tau}w_1 l_1 \qquad (31a)$$

$$\Rightarrow T_n = 2p_{d,1}x_{d,1}\tau(n-N) \qquad \Rightarrow T_N = 2\frac{\tau}{1+\tau}w_1(l_1 - L_1) \qquad (31b)$$

$$\Rightarrow T_I = 2p_{d,1}x_{d,1}\tau N \qquad \Rightarrow T_I = 2\frac{\tau}{1+\tau}w_1 L_1 \qquad (31c)$$

*Propositions:* *Given that trade is feasible, the volume of total, net and intra-industry trade are independent of the size of fixed export costs.*

*Given that trade is feasible, the volume of total trade, net and intra-industry trade vary inversely proportional to the variable export costs.*

Share of net an intra-industry trade to total trade

$$\Rightarrow \frac{T_n}{T_T} = \frac{2p_{d,1}x_{d,1}\tau(n-N)}{2n\tau p_{d,1}x_{d,1}} = \frac{n-N}{n} \qquad \Rightarrow \frac{T_n}{T_T} = \frac{l_1 - L_1}{l_1} \qquad (32a)$$

$$\Rightarrow \frac{T_I}{T_T} = \frac{2p_{d,1}x_{d,1}\tau N}{2n\tau p_{d,1}x_{d,1}} = \frac{N}{n} \qquad \Rightarrow \frac{T_I}{T_T} = \frac{L_1}{l_1} \qquad (32b)$$

*Proposition:* *Given that trade is feasible, the shares of inter- and intra-industry trade are neither dependent on the size of the fixed export costs nor on the size of the variable export costs.*

Inter- and intra-industry trade are determined by the number of varieties produced in the respective country and by how much they differ. This depends on the differences in their respective factor endowments. Whereas the volumes of total trade, intra- and inter-industry trade depend on the higher marginal costs of exporting, their ratio is unaffected. This is to say that they are affected proportionally.

However, as we know that countries have to be identical in order to achieve factor price equalisation, will we generalise the model hereafter to allow for different relative factor endowments and country size differences.

## The general case

Equilibrium selection (trading vs. autarky)

As in the case of identical countries, (19) can be rearranged, which yields the condition determining whether we observe an autarky or a trading equilibrium.

$$\Rightarrow \alpha + t \leq \left(\frac{1}{\sigma - 1}\right)\frac{1-\tau^2}{1-\tau\delta}\beta x_{d,1} \qquad (20a)$$

However, unlike in the case of identical countries, $\delta$ will typically not be equal to unity. Furthermore, $\delta$ is endogenous and is solely determined by the trade balance and its constraint. Hence, it is a priori very difficult to determine when exactly the equilibrium flips from autarky to trade. Separating the trade independent part from the trade dependent part yields:

$$\Rightarrow \alpha \leq \frac{1}{\sigma - 1}\beta x_{d,1} \qquad (20b)$$

$$\Rightarrow t \leq \left(\frac{1}{\sigma - 1}\right)\frac{\tau\delta - \tau^2}{1-\tau\delta}\beta x_{d,1} \qquad (20c)$$

Dividing (20b) by (20c) yields the following export entry condition:

$$\Rightarrow \frac{t}{\alpha} \leq \frac{\tau\delta - \tau^2}{1-\tau\delta} \qquad (20d)$$

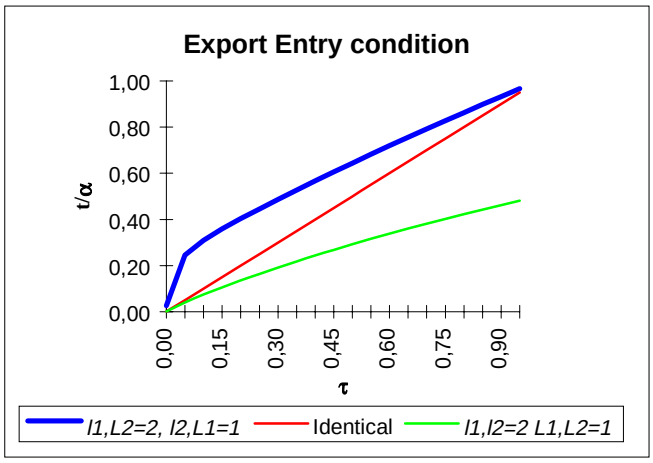
*Proposition:* *International trade will occur if the above inequality holds:*

The export entry condition for different scenarios is shown in Figure 4 below. As it can be seen, the entry condition will be affected by the differences in factor endowments and country sizes. This is due to the endogenous change of factor price differentials between countries, in order to satisfy the trade balance restriction.[16] If countries are identical with respect to economic size, but different with respect to their relative factor endowments, the entry condition lies north-westerly of the one for identical countries. The reason is that the home country, the net exporter of the differentiated product industry, has the relatively lower wage in the differentiated product industry. Hence, the more unequal countries are with respect to their relative factor endowments, the larger the fixed export costs can be relative to the variable trade costs without deterring the emergence of trade.

[16] See page 27 for the exact determination of $\delta$.

If countries differ with respect to their economic size, but are identical with respect to their relative factor endowments, the entry condition lies south-easterly of the one for identical countries. Here, the reason is that the larger country has the relatively higher equilibrium wage in the differentiated product industry. The larger these relative country size differences are, the smaller the fixed export costs have to be, for a given size of variable trade costs, in order to induce international trade. Moreover, as variable trade costs become smaller and smaller, the export entry condition will not move towards unity as in the other two scenarios, i.e. scenarios where countries have the same economic size.

Figure 4: Export entry conditions for countries with different factor endowments and country sizes




**Equilibrium number of firms:**

In reformulating (20a), it is straight forward to calculate the equilibrium number of firms in the industry.

$$l_1 = \sum_{i=1}^{n_1} l_{1,i} = n(\alpha + \beta x_{d,1} + t + (\beta + \gamma) x_{f,1})$$

$$l_2 = \sum_{j=1}^{n_2} l_{2,j} = \textit{Not defined}$$

Substituting (20a) into this equation and using our knowledge about relationship between $x_{d,1}$ and $X_{d,1}$ given by equation (18), the number of firms in the differentiated product industry in respective country emerges as:

$$\Rightarrow n = \frac{l_1}{\sigma(\alpha + t)} \qquad (21a)$$

As in the case of identical countries, a reduction of fixed export costs results in a rise in the equilibrium number of firms. Again, the equilibrium number of firms is independent of firms' output, and most surprisingly the wage ratio between two countries. Hence, the number of firms in respective equilibrium given by:

$$\Rightarrow n = \frac{l_1}{\sigma\alpha} \qquad \text{for} \qquad \frac{t}{\alpha} \succ \frac{\tau\delta - \tau^2}{1 - \tau\delta}$$

$$\Rightarrow n = \frac{l_1}{\sigma(\alpha + t)} \qquad \text{for} \qquad \frac{t}{\alpha} \leq \frac{\tau\delta - \tau^2}{1 - \tau\delta}$$

<u>Propositions</u>: *For some t and $\tau$, a marginal exogenous reduction of t will lead to a discontinuous reduction in the number of firms viable in industry 1.*

*Given that trade is feasible, a reduction in t will increase the number of firms viable in industry 1.*

Earlier we noted that, trade will result in more varieties being available for the consumer. This is the case if countries are identical. However, if the two countries in question differ with regard to their factor endowments or economic size this statement does not need to be true any more. Due to the higher total fixed costs when trading, the consequence may well be that, international trade reduces the number of domestically produced varieties by an amount that cannot be offset by the influx of imported varieties. In this case, the autarky equilibrium yields a larger variety choice, and thus a higher welfare level, than the corresponding trading equilibrium. The possibility of this phenomenon is solely attributed to the fixed export costs.[17]

As all varieties are traded, there are two effects, which together determine whether there will be a net variety increase or reduction for the home country. These are firstly, the size of the reduction in varieties produced in the home and foreign country respectively, and secondly the relative sizes of the differentiated product sector in the two countries. The smaller the differentiated product industry is, the smaller the reduction in domestically produced varieties will be in absolute terms.

[17] In a different setting Dixit and Norman (1980) derived a similar result. They argue that commodities produced with relatively low fixed cost will be replaced by products with relatively high fixed cost as the market expands. In their model, the effect arises due the ability of firms to choose the most profitable technology. In our context, however, this phenomenon is connected to the degree of economic integration and to different country sizes.

One important implication is that the country that produces fewer varieties in the autarky equilibrium, either because of smaller economic size and/or because of differences in relative factor endowments, will always receive a net increase in variety choice. To the contrary, the country with the absolutely larger autarky equilibrium number of varieties may suffer from a net reduction in variety choice.[18] This discussion can be formalised as follows. We denote the number of varieties available in autarky and trading equilibrium as $n_a$ and $n_t+N_t$ respectively.

$$\Rightarrow n_a = \frac{l_1}{\sigma\alpha} \qquad \text{for} \qquad \frac{t}{\alpha} \succ \frac{\tau\delta - \tau^2}{1-\tau\delta}$$

$$\Rightarrow n_t + N_t = \frac{l_1 + L_1}{\sigma(\alpha + t)} \qquad \text{for} \qquad \frac{t}{\alpha} \leq \frac{\tau\delta - \tau^2}{1-\tau\delta}$$

Moreover, we will assume that the home country has the larger differentiated product industry in absolute terms, either due to relative larger resource endowments or larger country size, i.e. $n \geq N$. Hence, an equation can be derived that determines whether the consumers will end up with more or less variety choice in a trading equilibrium. The following relationships determine the conditions in which trade yields a net gain in variety choice.

$$\Rightarrow \frac{n_a}{n_t + N_t} \leq 1 \qquad \Rightarrow \frac{t}{\alpha}\frac{l_1}{L_1} \leq 1 \qquad \text{(21b)}$$

**Firms' domestic, export and total revenue:**

$$\Leftrightarrow p_{d,1}x_{d,1} = \sigma\alpha w_1 \qquad \text{for} \qquad \frac{t}{\alpha} \succ \frac{\tau\delta - \tau^2}{1-\tau\delta}$$

$$\Rightarrow p_{f,1}x_{f,1} = 0 \qquad \text{for} \qquad \frac{t}{\alpha} \succ \frac{\tau\delta - \tau^2}{1-\tau\delta}$$

$$\Leftrightarrow p_{d,1}x_{d,1} = \sigma(\alpha + t)\frac{1-\tau\delta}{1-\tau^2}w_1 \qquad \text{for} \qquad \frac{t}{\alpha} \leq \frac{\tau\delta - \tau^2}{1-\tau\delta} \qquad \text{(22a)}$$

$$\Rightarrow p_{f,1}x_{f,1} = \sigma(\alpha + t)\frac{\tau\delta - \tau^2}{1-\tau^2}w_1 \qquad \text{for} \qquad \frac{t}{\alpha} \leq \frac{\tau\delta - \tau^2}{1-\tau\delta} \qquad \text{(22b)}$$

$$\Rightarrow p_{d,1}x_{d,1} + p_{f,1}x_{f,1} = \sigma(\alpha + t)w_1 \qquad \text{for} \qquad \frac{t}{\alpha} \leq \frac{\tau\delta - \tau^2}{1-\tau\delta} \qquad \text{(22c)}$$

[18] This can be illustrated with an easy example. Assume that the home country is twice as large as the foreign country, further assume that there are fixed cost of trade, which in size are as large as the industry specific fixed cost, and that there are no variable transport costs. The effect of international trade will be that the home country loses half of its domestically produced varieties, and imports a half of foreign produced varieties,

Hence, an increase in either the fixed export costs, or the elasticity of substitution between product pairs, will lead to a rise in both domestic and export revenue, and thus in firms' total revenue.

Surprisingly, total revenue of a representative domestic firm is independent of the foreign wage in the differentiated product industry. This means that, whereas domestic and export revenues are affected by changes in the wage ratio if looked at separately, the combined effect is such that the separate effects cancel out. However, as we will see later, due to general equilibrium constraint, both the wage ratio and the wage rate are affected by changes in variable trade costs. Hence, total revenue will not be independent of the degree of economic integration.

<u>Propositions:</u> *Given the feasibility of trade, the larger the fixed export costs are, the larger domestic, export and total revenue will be.*

*Firms' total revenue will be larger in a trading equilibrium than in autarky.*

*Total revenue is independent of the wage ratio between different countries.*

It is very difficult to determine a priori how a change in the variable export costs $\tau$ affects the wage ratio $\delta$ between the two countries. Nevertheless, it is possible to derive restrictions for the equilibrium wage ratio relative to the variable transport costs. As domestic revenue is not allowed to be negative, the restriction $\delta \leq 1/\tau$ can be derived. Furthermore, as total revenue is independent of the wage ratio between the countries, and as the ratio of domestic revenue to total revenue is not allowed to exceed unity, it follows that $\delta \geq \tau$ has to be true. Taking both restrictions together yields:[19]

$$\tau \leq \delta \leq 1/\tau$$

<u>Proposition:</u> *Given that trade is feasible, further economic integration, i.e. through a reduction in variable trade costs, will eventually lead to a reduction in factor price differentials between countries.*

If this restriction is not met, trade will not be feasible. One implication is that the restriction $t/\alpha \leq 1$ is still valid. As $\tau$ is an inverse measure of variable trade barriers, it

---

which are identically priced. Hence, the home country ends up with 0.75 times its original variety choice, a clear welfare loss, while the smaller foreign country ends up with 1.50 times its original variety choice.

[19] This restriction holds for all revenue and output functions.

follows immediately that, if trade is feasible, further economic integration will eventually lead to convergence of factor price differentials. $\tau$ will increase in value, while $1/\tau$ will decrease, as economic integration progresses. This in turn reduces the factor price differential between the two countries. However, the convergence of factor price differentials is not necessarily a monotonic relationship of variable trade costs.

**Firms' domestic, export and total output:**

$$\Leftrightarrow x_{d,1} = (\sigma - 1)\frac{\alpha}{\beta} \qquad \text{for} \qquad \frac{t}{\alpha} \succ \frac{\tau\delta - \tau^2}{1 - \tau\delta}$$

$$\Leftrightarrow x_{f,1} = 0 \qquad \text{for} \qquad \frac{t}{\alpha} \succ \frac{\tau\delta - \tau^2}{1 - \tau\delta}$$

$$\Leftrightarrow x_{d,1} = (\sigma - 1)\frac{\alpha + t}{\beta}\frac{1 - \tau\delta}{1 - \tau^2} \qquad \text{for} \qquad \frac{t}{\alpha} \leq \frac{\tau\delta - \tau^2}{1 - \tau\delta} \qquad \text{(24a)}$$

$$\Leftrightarrow x_{f,1} = (\sigma - 1)\frac{\alpha + t}{\beta}\frac{\tau\delta - \tau^2}{1 - \tau^2}\tau^{\frac{1}{\sigma - 1}} \qquad \text{for} \qquad \frac{t}{\alpha} \leq \frac{\tau\delta - \tau^2}{1 - \tau\delta} \qquad \text{(24b)}$$

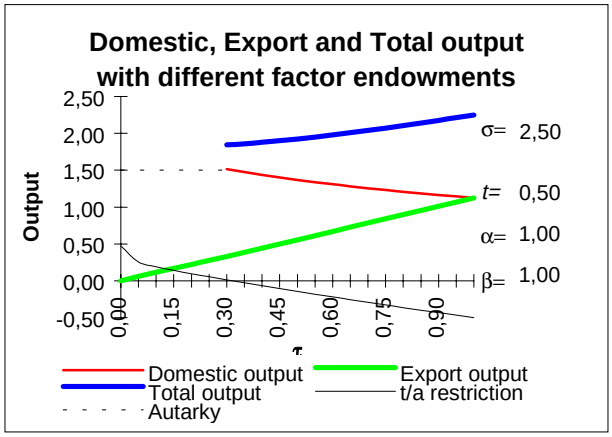
*Propositions:* *Given the feasibility of trade, the larger the fixed export costs and the larger the variable transport costs are, the larger domestic output per firm will be.*

*Given the feasibility of trade, the larger the fixed export costs and the smaller the variable transport costs are, the larger domestic output per firm will be.*

Hence, both larger economies of scale, as reflected by $(\alpha + t)/\beta$, and a higher the degree of substitutability between varieties, increase the domestic and total output per firm. It is important to note that, due the fact that exported varieties are priced higher than domestic varieties, the export revenue function has to be multiplied by the ratio of the domestic to export price index. Thus, when export output is represented in terms of the domestic price index, the export output will be smaller by the fraction $\beta/(\beta + \gamma)$. In fact, this merely represents that transport costs have to be encountered.

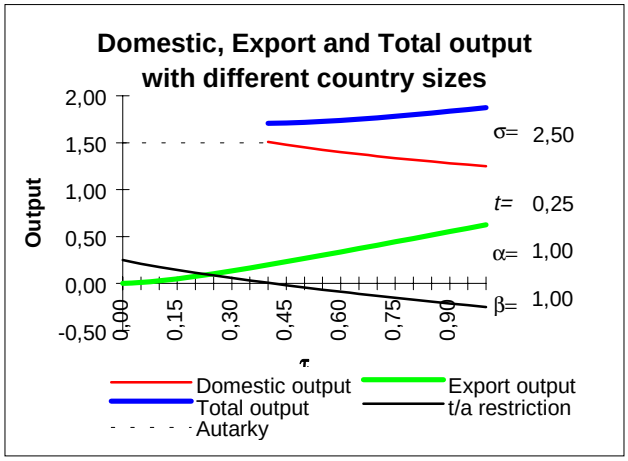
Furthermore, due to the aforementioned necessity of multiplying export output by the ratio of the domestic to the export price level, total output per firm will be affected by variable trade costs.

Figure 5: Relationship between variable export cost and firms' output: The case of different factor endowments




Figures 5 and 6 show the domestic, export and total output per firm in two different cases. In Figure 5, countries are assumed to be of identical size, but different with respect to their relative factor endowments, while in the Figure 6 the opposite holds true. Trade is feasible throughout the range where the t/a restriction is negative. In the positive range the autarky output level prevails. As countries have the same economic size, individuals will consume the same amount of domestic and foreign varieties in a trading equilibrium with zero variable export costs.

Figure 6: Relationship between variable export cost and firms' output: The case of different country sizes




Differently, if countries are unequal in size, as shown in Figure 6. It is assumed that the home country is twice as large as the foreign country. Hence, if variable trade costs are zero, 2/3 of total output will be domestic output, while 1/3 will be exported.

## International trade structure

### Expenditure and factor income

The next steps are to calculate the income and expenditure of the home country. We use the knowledge that they must be of equal size in equilibrium, in order to derive the trade balance. Solving the trade balance for the equilibrium wage rate allows us to examine how different relative factor endowments and country sizes affect the volume of total trade and sectoral trade structure.

The expenditure of the home country is given by the consumption of the homogenous product plus the domestic and imported varieties of the differentiated product industry.

$$\Rightarrow p_2 c_2 + n p_{d,1} x_{d,1} + N P_{f,1} X_{f,1} = e$$

Substituting (9a), (10a) and (16b) into the function above yields:

$$\Leftrightarrow p_2 c_2 + (n + \tau\delta^{\frac{1-\sigma}{\sigma}} N) p_{d,1} x_{d,1} = e \qquad (26)$$

The factor income of the country can be calculated in using the full employment condition and the knowledge about the number of firms in equilibrium.

$$\Rightarrow w_1 l_1 + w_2 l_2 = w_1 n \sigma(\alpha + t) + p_2 x_2$$

Using the equations (22a) and (8a) yields:

$$\Rightarrow w_1 l_1 + w_2 l_2 = p_{d,1} x_{d,1} n \left[\frac{1-\tau^2}{1-\tau\delta}\right] + p_2 x_2 \qquad (27)$$

### Trade balance

In equilibrium, factor income must equal expenditure. In equilibrium, the trade balances of both countries are zero. Furthermore, net exports from the home country have to equal net imports to the foreign country in the respective industry, and vice versa. The trade balance in the home country is given by:

$$\Leftrightarrow p_{d,1} x_{d,1} \left[\left(\frac{\tau\delta - \tau^2}{1-\tau\delta}\right) n - \tau\delta^{\frac{1-\sigma}{\sigma}} N\right] + p_2 (x_2 - c_2) = 0 \qquad (28a)$$

We assume without loss of generality that $n \geq N$. It follows that $p_2 (x_2 - c_2)$ represents the amount of net imports of the homogenous product from the foreign country, while $p_{d,1} x_{d,1} \left[\left(\frac{\tau\delta - \tau^2}{1-\tau\delta}\right) n - \tau\delta^{\frac{1-\sigma}{\sigma}} N\right]$ denotes the amount of net exports to the foreign country.

The home country exports *n* varieties, while importing *N* varieties. Substituting (21a) and (22a) leads to:

$$\Leftrightarrow w_1\left(\frac{\tau}{1-\tau^2}\right)\left[(\delta-\tau)\,l_1-(1-\delta\tau)\delta^{\frac{1-\sigma}{\sigma}}\,L_1\right]+\chi w_2\,l_2-(1-\chi)w_1\,l_1=0 \qquad (28b)$$

Due to the general equilibrium nature, we know that this is automatically true for the foreign country. Furthermore, it is known that the home country's net imports of the homogenous good are of equal value to their corresponding net exports from the foreign country. This can be seen as the constraint for the previous trade balance.

$$\Rightarrow p_2(x_2-c_2)=-P_2(X_2-C_2) \qquad \text{with } w_2=W_2$$

$$\Leftrightarrow w_1=\frac{w_2\chi(l_2+L_2)}{(1-\chi)(l_1+\delta^{\frac{1}{\sigma}}L_1)} \qquad (29)$$

Selecting $w_2=1$ as numéraire and substituting (29) into (28b) yields the final equation that can be solved for $\delta$. After having solved for $\delta$, $w_1$ can be solved for by substituting $\delta$ into (28b). Subsequently $W_1$ can be solved for by using the relationship $\delta=\left(\frac{w_1}{W_1}\right)^{-\sigma}$.

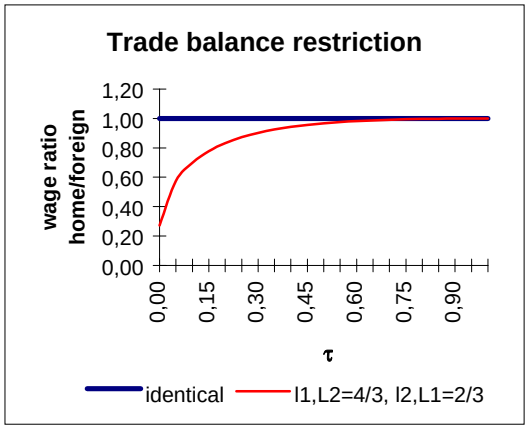
**Factor endowment differences**

Figure 7 below shows how the relative wage rate between the two countries is affected, if the variable trade costs are reduced. It is assumed that firstly, the two countries are equal in economic size, i.e. the total factor endowments are of the same value, and secondly that the home country has a comparative advantage in the differentiated product industry. Thus, the home country will become a net exporter in differentiated products in a trading equilibrium.

It seems surprising at first sight that $w_1/W_1\leq 1$ for positive variable export costs. Nevertheless, this result can intuitively be explained, when considering the implications of these differing factor endowments. Both countries are consuming the same number of varieties, given that trade is feasible. Furthermore, the variable trade costs, that have to be incurred, are the same for both home and foreign country firms, given the countries pay the same wage. However, the number of firms that have to incur these costs is larger in the home country, as it was assumed that $n\geq N$. Hence, the total variable trading costs incurred by the home country are also larger. Knowing that trade in the homogenous good sector is free, yields the implication that trade can only be balanced if this fact is offset by the home country

paying a smaller wage in industry 1 than the foreign country. Given that trade is feasible, an increase in the variable trade costs will tend to raise the wage differential in industry 1 between the two countries.

Figure 7: The relationship between variable trade costs and factor price differences: The case of different factor endowments




**Country size differences**

Once we introduce different country sizes, the possibility arises that a country has a '*false*' comparative advantage; a phenomenon that was introduced into the literature by Lancaster (1980). This is phenomenon is best explained considering two economies, which are identical except with respect to their size. The apparent effect is that pre-trade prices for differentiated products in the larger country are less expensive than in the smaller country, due to the downward sloping average cost curve. Hence, pre-trade prices fail to reliably predict the pattern of trade. In case of positive trade costs, Lancaster (1980) argues for the two country, two industries case, where the first industry is characterised by product differentiation, and increasing returns to scale, while the second is a homogenous product industry operating with constant returns to scale, that the larger country will become a net exporter in the differentiated product industry and will import the homogenous good in return. However, if countries are with fully integrated, only intra-industry trade will emerge, as neither country has got a comparative cost advantage over the partner country.

As the technologies are assumed to be identical in both countries, the only way false comparative advantage can be generated in our model is through countries' relative wage in the differentiated product sector. The trade balance, and thus the relative factor endowments, and the degree of economic integration determine the relative wage in industry 1, which in

turn determines firms' output. One major implication is that, country size differences also serve as one of the factors determining the emergence of international trade.

Figure 8: The relationship between variable trade cost and factor price difference: The case of country size differences

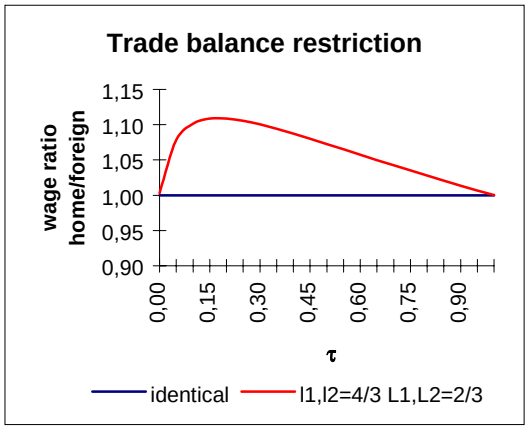



Figure 8 above shows how the wage ratio is affected with altering degrees of economic integration on the variable cost side. Intuitively, one should expect that the larger country has the higher equilibrium wage rate. The reason is that the ratio of domestic to export output is relatively larger for firms in the larger country. Consequently, the total variable trade costs that, have to be incurred, are smaller for individual firms in the larger country. Subsequently, firms pay a higher equilibrium wage to their workers. As the larger country produces more varieties than the smaller country, more firms have to incur variable export costs. Hence, in equilibrium, these two effects counteract each other. The difference is that in the smaller country, this amount is spread over fewer firms.

**International trade structure**

The relevant issue in this section is to determine how different factor endowments and country sizes affect the sectoral pattern of trade, i.e. intra- and inter-industry trade, and the volume of trade. For simplicity, we will assume that the home country is either the larger country and/or has a comparative advantage in the differentiated product industry. This assumption ensures firstly that the following trade volumes are presented correctly, and secondly that the home country will be the net exporter of the differentiated product. However, the comparative advantage in the differentiated product industry may lie with the smaller country. Thus, the larger country may become the net exporter of the homogenous

product, despite having the absolutely larger differentiated product industry. Knowing that the trade balance also determines which country will become the net exporter of the homogenous product, we can account for such scenarios in simply adjusting the expressions for the trade volumes. Thus, this restriction does not reduce the generality of the results.

Furthermore, it will not be clear from the following expressions alone whether countries differ in economic size or not. Although it is true that following equations do not distinguish between factor endowment and country size differences, the wage ratio, which has endogenously been determined in the trade balance, will not be the same. Hence, the volumes of net, intra-industry and total trade will be different. Following (28a), the subsequent expressions for total trade, net trade and intra-industry trade emerge as:

The volume of net, intra-industry and total trade

$$\Rightarrow T_T = T_N = T_I = 0 \qquad \text{for} \quad \frac{t}{\alpha} \succ \frac{\tau\delta - \tau^2}{1-\tau\delta}$$

$$\Rightarrow T_T = 2p_{d,1}x_{d,1}\left(\frac{\tau\delta - \tau^2}{1-\tau\delta}\right)n \qquad \text{for} \quad \frac{t}{\alpha} \leq \frac{\tau\delta - \tau^2}{1-\tau\delta} \qquad (31a)$$

$$\Rightarrow T_N = 2p_{d,1}x_{d,1}\left(\frac{\tau\delta - \tau^2}{1-\tau\delta}n - \tau\delta^{\frac{1-\sigma}{\sigma}}N\right) \qquad \text{for} \quad \frac{t}{\alpha} \leq \frac{\tau\delta - \tau^2}{1-\tau\delta} \qquad (31b)$$

$$\Rightarrow T_I = 2p_{d,1}x_{d,1}\tau\delta^{\frac{1-\sigma}{\sigma}}N \qquad \text{for} \quad \frac{t}{\alpha} \leq \frac{\tau\delta - \tau^2}{1-\tau\delta} \qquad (31c)$$

As the volume of total trade is measured by the addition of exports and imports, and as total imports have to be of equal value to total exports, the expression for total trade is simply twice the value of total exports by the country with the absolutely larger differentiated product industry.[20] The volume of total trade depends on domestic revenue generated by each individual firm multiplied by the number of varieties, in the industry.

The volume of net- or inter-industry trade is determined by the same variables as total trade. However, the difference is that the amount of inter-industry trade is determined by the differences in factor endowments, and thus varieties produced in the differentiated product sector. This includes country size differences. The greater this difference is the more inter-industry trade will occur. At the extreme, if the differentiated product industry is not viable at all in the foreign country, all international trade would be of inter-industry kind. The home

[20] This is due to the fact that there is only one-way trade in the homogenous product sector.

country would export half of its output industry 1 and import the homogenous product to the same extent.

The volume of intra-industry trade is determined by the amount of '*overlap*' or similarity between the two countries. Again, this includes both factor endowments and country sizes. The larger the absolute number of varieties produced in the foreign country is (remember that $n \geq N$ due to assumption), the larger the volume of intra-industry trade will be.

It seems as though domestic revenue and the number of varieties are offsetting each other. Substituting both equations (21a) and (22a) yields the following expressions:

$$\Rightarrow T_T = 2\frac{\tau\delta - \tau^2}{1-\tau^2} w_1 l_1 \qquad (32a)$$

$$\Rightarrow T_N = 2w_1 \frac{\tau}{1-\tau^2}\left((\delta - \tau) l_1 - (1-\tau\delta)\delta^{\frac{1-\sigma}{\sigma}} L_1\right) \qquad (32b)$$

$$\Rightarrow T_I = 2w_1 \frac{\tau}{1-\tau^2}(1-\tau\delta)\delta^{\frac{1-\sigma}{\sigma}} L_1 \qquad (32c)$$

Hence, a reduction in fixed export costs results in a reduction in domestic revenue by an amount which is *offset* by an increase in the number of firms. In other words, economies of scale are necessary for the emergence of intra-industry trade, but its size (as measured by the ratio of fixed costs to marginal costs) has neither an effect on the volume of net trade, nor intra-industry trade, nor total trade.

*Propositions:*

*Given that trade is feasible, the volume of net, intra-industry and total trade is neither dependent on the size of fixed export costs nor the size of economies of scale.*

*The larger the factor endowment differences are, the larger the volume of net trade will be, and the smaller the volume of intra-industry trade will be.*

Therefore, total trade only depends on the size of the country with the larger differentiated product industry, the level of the wage rate paid in this industry, and an

expression which is dependent on the size of the variable trade costs and the relative wage rate in the differentiated product industry.

The volume of international trade will be low if $\tau$ is close to zero, while if $\tau$ is close to 1 trade will be virtually free. This is exactly what we should have expected. Moreover, with

free trade the amount of trade will equal the factor income in the differentiated product industry, i.e. $w_1 l_1$.

In the Figure 9, it is shown how the structure of intra- and inter-industry trade is affected by a reduction in variable trade costs. The fixed export costs are chosen, such that trade is feasible throughout the range shown in the diagram. Furthermore, it is assumed that the countries have the same economic size, i.e. their respective total factor endowments are identical. As expected, with zero variable trade costs, the volumes of inter- and intra industry trade are identical. However, the diagram shows nicely that the volumes of intra-and inter-industry trade are not affected proportionally. Trade liberalisation has a positive effect on the share of intra-industry trade to total trade.

Figure 9: The relationship between variable trade costs and trade structure: The case of different factor endowments

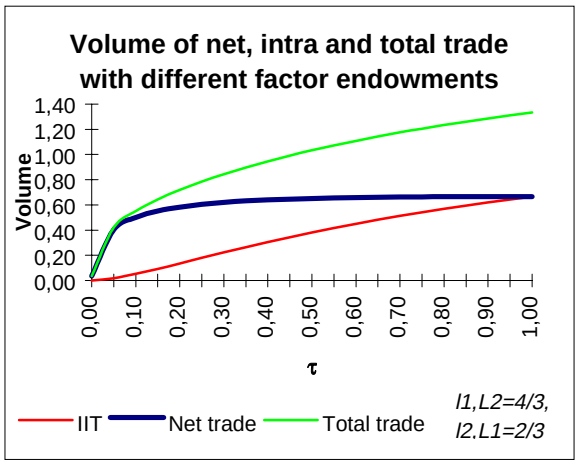
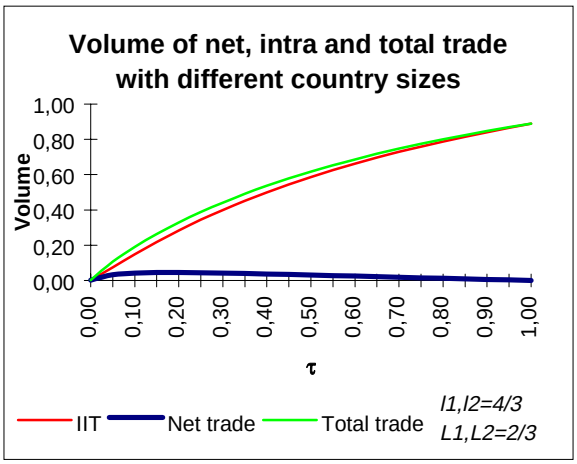



Figure 10 shows the effect of country size differences. Again, the fixed export costs are such that trade is feasible throughout the range shown in the diagram. Starting with zero variable trade costs, only intra-industry trade will emerge. Increasing variable trade cost leads to the additional emergence of inter-industry trade. The relationship between variable trade costs and the volume of inter-industry trade will take the form of a hump.

Figure 10: The relationship between variable trade cost and trade structure: The case of different country size




Share of net trade and intra-industry trade to total trade

$$\Rightarrow \frac{T_N}{T_T} = 1 - \delta^{\frac{1-\sigma}{\sigma}} \frac{1-\tau\delta}{\delta-\tau} \frac{N}{n} \qquad (32a)$$

$$\Rightarrow \frac{T_I}{T_T} = \delta^{\frac{1-\sigma}{\sigma}} \frac{1-\tau\delta}{\delta-\tau} \frac{N}{n} \qquad (32b)$$

*Propositions:* *Given that trade is feasible, the shares of inter-industry and intra-industry trade to total trade are independent of the size of fixed export costs.*

*Given that trade is feasible, the more dissimilar countries are with respect to their factor endowment, the larger the share of inter-industry trade to total trade will be and the smaller the share of IIT to total trade will be.*

The shares of intra-industry and net trade to total trade are also independent of the fixed costs $\alpha + t$. Similarly, to the analysis above, the more similar countries are with respect to their factor endowments the lower the share of inter-industry trade in total trade will be.

The shares of inter- and intra-industry trade to total trade are determined by the factor price differential in sector 1 in both countries, which in turn depends on the variable trade costs, the differences in countries' respective factor endowments and country sizes. Similar to the volume of total, net and intra-industry trade, the shares of net trade and intra-industry trade to total trade are independent of the size of fixed export costs.

## Concluding remarks

This model analyses the effects of non-tariff barriers on the structure of trade and industry. It is argued that non-tariff barriers typically include both fixed and variable cost components. Due to the introduction of fixed export costs, the industrial structure might undergo significant changes when trade barriers are reduced beyond a certain threshold. The equilibrium number of firms changes, and the equilibrium type flips. This to say that autarky equilibrium will suddenly change to a trading equilibrium. As a result of the fixed export costs that trading firms have to incur, the number of domestic firms will fall.

Concerning the volume and structure of international trade, it has been shown that the crucial point is which type of trading costs are reduced. While the fixed export costs have the ability to change equilibrium industry structure, they do neither affect the volume of trade, nor its structure. Hence, given that trade is feasible, a further increase in economic integration, which is primarily channelled through fixed cost reduction, will not affect the share of intra-industry trade to total trade. The variable export costs, however, have an effect on both the volume and structure of trade. The reason for this is that the equilibrium wage ratio between the two countries is affected by the reduction of the variable trade costs. The change in the wage ratio in turn affects the trade structure.

Moreover, country size differences matter. If countries differ in size, economic integration via a reduction in variable transport costs affects the structural trade pattern, despite both countries being identical with regard to the relative factor endowments. In case of positive trade barriers, the relatively larger country will enjoy a false comparative advantage. This is to say that the larger country will become a net exporter of the differentiated product and a net importer of the homogenous product. If economic integration is increased, i.e. through a reduction of variable trade costs, the volume of inter-industry trade may actually rise in the beginning. However, eventually it will shrink until it has disappeared completely. This is the case of complete economic integration. Throughout this integration process, the volume of intra-industry trade will rise. The existence of false comparative advantage effects is fairly well known in the literature. Nevertheless, to best of my knowledge the model presented here is the first theoretical model that is able to formally derive such effects.

Given that trade is feasible, it has additionally been shown that, economic integration on the variable cost side will eventually reduce factor price differentials between the

countries. However, this is not to say that this is necessarily a monotonic relationship. As in the case of different country sizes, it will be first the case that the wage differential widens, however stays within the permissible band, and starts to fall thereafter until factor price equalisation is achieved in a trade equilibrium with zero variable trade costs.

And finally, a point that is not related to economic integration; contrary to the common view that the volume and share of intra-industry trade to total trade are related to the size of economies of scale, we derive the result that they are not related to, i.e. are independent of, the size of economies of scale. This does, however, not reduce the importance of economies of scale, as they are necessary for intra-industry trade to emerge.

## Bibliography:

**Armington, Paul S. (1969):** A Theory of Demand for Products Distinguished by Place of Production, in International Monetary Fund Staff Papers, Vol. 16, pp. 159-178

**Dixit, Avinash and Stiglitz, Joseph (1977):** Monopolistic Competition and Optimum Product Diversity, in American Economic Review, Vol. 67, No. 3, pp. 297-308

**Dixit, Avinash and Norman, Victor (1980):** Theory of International Trade: A Dual , General Equilibrium Approach, (Cambridge: Cambridge University Press)

**Emerson, Michael, Aujean, Michel, Catinat, Michel, Goybet, Philippe and Jacquemin, Alexis (1988):** The Economics of 1992: The E.C. Commission's Assessment of the Economic Effects of Completing the Internal Market, (Oxford: Oxford University Press)

**Helpman, Elhanan (1981):** International Trade in the Presence of Product Differentiation, Economies of Scale and Monopolistic Competition: A Chamberlin-Heckscher-Ohlin Approach, in Journal of International Economics, Vol. 11, pp. 305-340

**Helpman, Elhanan and Krugman, Paul (1985):** Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition, and the International Economy, (Cambridge Mass.: MIT Press)

**Helpman, Elhanan and Krugman, Paul (1989):** Trade Policy and Market Structure, (Cambridge Mass.: MIT Press)

**Krugman, Paul R. (1979):** Increasing Returns, Monopolistic Competition, and International Trade, in Journal of International Economics, Vol. 9, pp. 469-479

**Krugman, Paul R. (1980):** Scale Economies, Product Differentiation, and the Pattern of Trade, in American Economic Review, Vol. 70, No. 5, pp. 959-973

**Krugman, Paul R. (1981):** Intraindustry Specialization and the Gains from Trade, in Journal of Political Economy, Vol. 89, No. 5, pp. 959-973

**Lancaster, Kelvin (1980):** Intra-Industry Trade under Perfect Monopolistic Competition, in Journal of International Economics, Vol. 10, pp. 151-175

**Venables, Anthony J. (1994):** Integration and Export Behaviour of Firms - Trade Costs, Trade Volumes and Welfare, in Weltwirtschaftliches Archiv, Vol. 130, No. 1, pp. 118-132