Ph.D. Dissertation in Economics:

INTERNATIONAL TRADE IN THE MANUFACTURING SECTORS OF INDUSTRIALISED COUNTRIES: THEORY AND EVIDENCE

Candidate: Mynyre Amiti

London School of Economics and Political Sciences

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ABSTRACT

The Thesis investigates the determinants and patterns of specialisation and international trade in the manufacturing sectors of countries that are similar in terms of their technology, relative factor endowments and preferences.

Chapter 1 shows that differences in country size alone can be a basis for inter-industry trade in manufactures. I present a general equilibrium model in which each country has two imperfectly competitive industries which can differ in three respects: relative factor intensities, level of transport costs and demand elasticities. With positive trade costs and increasing returns to scale, each firm prefers to locate in the larger country due to the 'market access' effect. But the increase in demand for factors in the large country induces a 'production cost' effect - a rise in the wage in the large country relative to the small country to offset the locational advantage of the large country. The tension between the market access effect and production cost effect determines which industry will concentrate in which country and the pattern of inter-industry trade.

Chapter 2 investigates circumstance in which technological leapfrogging between regions will occur. Input-output linkages between firms in imperfectly competitive industries create forces for agglomeration of industries in particular locations. A new technology, incompatible with the old, will not benefit from these linkages, so will typically be established in locations with little existing industry and consequently lower factor prices.

Chapters 3 studies specialisation patterns in the European Union between 1968 and 1990. It investigates whether specialisation has increased in the European Union countries and analyses whether these patterns are consistent with three

different strands of trade theories: the classical Heckscher-Ohlin theory, the 'new' trade theories based on increasing returns to scale, and the 'economic geography' theories based on vertical linkages between industries. I find that there is evidence of increasing specialisation in the European Union countries and there is some support for all three strands of trade theories.

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INTRODUCTION

Nearly half of world trade takes place between industrialised countries, with a significant proportion in manufactures. The purpose of the Thesis is to investigate the determinants and patterns of specialisation and international trade in the manufacturing sectors of countries that are similar in terms of their technologies, factor endowments and preferences.

Classical trade theory sees little basis for trade between similar economies - it postulates that countries trade to take advantage of their differences. The basic idea, which dates back to Ricardo in 1817, is that each country has a comparative advantage in producing different goods - some goods can be produced more cheaply in different countries - and this gives rise to profitable opportunities for trade. According to the Ricardo theory, each country will specialise[1] and export the goods in which it has a comparative advantage arising from differences in technologies. The theory does not explain why countries have access to different technologies, it is assumed that they do. In contrast, comparative advantage arises from different relative factor endowments in the Heckscher-Ohlin model. So capital abundant countries specialise in and export capital intensive goods and labour abundant countries specialise in and export labour intensive goods.

Classical trade theory has contributed a great deal in explaining inter-industry trade between dissimilar countries. However its inability to explain international trade flows between similar countries motivated a search for a new framework.

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[1] When I refer to specialisation this does not necessarily imply complete specialisation.

A 'new trade theory' developed which explains why identical countries engage in intra-industry trade - two way trade within the same industry. Krugman (1979) uses a simplified Spence-Dixit-Stiglitz model of product differentiation to show that identical countries may trade to take advantage of scale economies. When countries move from autarky to free trade the number of varieties of goods in each country falls, enabling firms to slide down their average cost curves. So there are gains from trade due to lower unit cost of production and consumers have access to more varieties through trade. In Ethier (1979, 1982) intra-industry trade in intermediate goods can take place between identical countries with scale economies arising from an increased division of the production process into a large number of distinct operations. Brander and Krugman (1983) show that efforts of oligopolistic firms to raid each others markets will lead to intra-industry trade in homogenous goods between identical countries.

The 'new economic geography' literature, building on the new trade theory, shows that inter-industry trade can take place between countries which only differ in size. Krugman (1991a) formalises ideas dating back to Myrdal (1957) and Hirschman (1958) to analyse the circumstances under which a manufacturing sector will agglomerate in a limited number of locations. The ideas relate to what Myrdal (1957) called 'circular causation' which is created by what Hirschman (1958) called 'backward linkages'. In a two region, two sector general equilibrium model where manufactures are subject to increasing returns to scale and the other sector is perfectly competitive with constant returns to scale, each manufacturing good will only be produced at one location to save on fixed costs. With other things equal, the preferred site will be the one with large demand to minimise on transport costs, and demand will be large where the manufacturing sector is located since demand also comes from the manufacturing sector. With labour mobile between the two regions, this 'backward linkage' is reinforced by a 'forward linkage' arising from workers preferring to live in a location where manufacturing is concentrated because goods are less expensive there. For some parameter values, all the manufacturing sector will agglomerate in one region, exporting manufactured goods and importing goods from the perfectly competitive sector.

In a further development in the new economic geography literature, Krugman and Venables (1995) and Venables (1996a) show that agglomeration of manufacturing industries may arise due to vertical linkages between two imperfectly competitive industries, so circular causation can arise without labour mobility between regions. A large number of downstream firms attract a large number of upstream firms due to 'demand linkages', and the more upstream firms in the one location the lower the cost of inputs to downstream firms providing a feedback effect which is referred to as a 'cost' linkage. The feedback effect may come from downstream firms having access to a bigger variety of differentiated inputs, as in Krugman and Venables (1995) and Venables (1996a) or as a result of more intense competition, arising from a higher number of upstream firms in the one location, reducing the price of upstream goods as in Venables (1996b). So the agglomeration forces in the new economic geography literature arise from pecuniary externalities.

These three strands of trade theory can be seen as complementary explanations of world trade flows: the Classical trade theories explain inter-industry trade between dissimilar countries; the new trade theories explain intra-industry trade between similar countries; and the new economic geography theories explain inter-industry trade between similar countries. But what is the basis of inter-industry trade within the manufacturing sector between similar countries? Why do certain manufacturing industries agglomerate in one location and other manufacturing industries in other locations? This question is closely related to Marshall's (1890) concept of industry localisation. Marshall explained that industries localise due to external economies: with several firms agglomerated in one location the probability of unemployment and the probability of labour shortages is lower due to the pooled market for workers with industry specific skills; localised industries can support the production of non-tradeable specialised inputs; and informational spillovers are more likely when firms are located in the one location. (See Hoover (1948)).

Chapter 1 addresses whether differences in country size can generate inter-industry trade within the manufacturing sector between two countries which are identical in technologies, relative factor endowments and tastes; and it determines the relationship between the size of the country and the goods it produces and trades. It builds on a model by Krugman (1980) where he demonstrates two results. The first result states that if countries are identical in all respects except for size, with other things equal, the large country will have a higher wage. Firms prefer to locate in only one location to save on transport costs and if production costs were the same in each country firms would prefer to locate where demand is the largest to save on transport costs. To maintain labour market equilibrium, the smaller country must offset its locational disadvantage by offering a wage differential. The second result states that each country will be a net exporter of goods it has the relatively larger domestic market - the 'home market' effect. Both countries are of equal size with two imperfectly competitive industries and consumers in each country are assumed to have different preferences. So each industry will concentrate in the country which has the highest demand for its products and the country becomes a net exporter of goods from that industry. Jones (1970) also considered how different consumer tastes affect the pattern of trade.

In Chapter 1, I abandon the assumption of different consumer tastes that is present in Krugman (1980) and allow the two manufacturing industries to differ in three respects: in terms of relative factor intensities, the level of trade costs and demand elasticities. I present a general equilibrium model with two countries which are endowed with identical relative endowments of capital and labour, but different in absolute levels, have the same technology in two imperfectly competitive industries, and whose consumers have identical tastes. The forces present in Krugman (1980) and also in Krugman and Venables (1990) and Krugman (1991a) are critical in my model. There is a 'market access' effect which attracts firms to the large market - Krugman's (1980) home market effect; and a 'production cost' effect which attracts firms to the small market due to the lower wage there. The tension between the market access effect and the production cost effect determine the pattern of specialisation and inter-industry trade. And the relative strength of these two forces depends on how the two industries differ.

When industries differ with respect to factor intensities, the large country is a net exporter of capital intensive goods and the small country is a net exporter of labour intensive goods, with capital flowing from the small country to the large country. See Markusen (1983) for an analysis of a variety of cases where factor movements and commodity trade are complements. When industries differ with respect to transport cost or demand elasticities, there are no capital movements. Even though the endowments of capital to labour remain the same there is inter-industry trade between the two countries with the large country a net exporter of high transport cost goods and the small country a net exporter of low transport cost goods. When industries differ with respect to demand elasticities the large country has positive net exports of high elasticity goods when integration levels are close to autarky or free trade levels; and it is a net importer of high elasticity goods at intermediate levels of integration.

Chapter 2 analyses the circumstances under which a leading industrial region loses its dominant position to a lagging region, after there has been some major technological breakthrough. Suppose that a vertically linked industry is agglomerated in the one region due to the demand and cost linkages formalised in the economic geography literature. Then a new technology becomes available which is superior to and incompatible with the old technology. Will the new technology be adopted in the region which already has the vertically linked industries operating with the old technology or in the region that has none of these industries? I show that the new technology is most likely to be adopted in the lagging region where the wages are lower. The new technology does not benefit from the agglomeration of firms in the leading region since the two technologies are assumed to be incompatible. This creates the possibility for technological leapfrogging. We also see that the two technologies may co-exist or the new technology may lead to the disappearance of the industries operating with the old technology. There are multiple equilibria arising from pecuniary externalities. If firms were able to co-ordinate their actions, then the firms in the leading region would immediately adopt the new technology.

Other papers have also addressed the issue of technological leapfrogging. Brezis, Krugman and Tsiddon's (1993) explanation of technological leapfrogging among countries is based on non-pecuniary externalities. They assume that production is subject to external learning effects which are specific to each country and that when there is a major technological breakthrough, it yields a higher productivity than the old technology given the same amount of experience. So for the leading country which has extensive experience with the old technology and hence a higher wage, the new technology is initially inferior to the old. In contrast, the lagging country, which has little experience with the old technology and hence a lower wage, can use its wage advantage to adopt the new technology. Over time, the lagging country gains more experience with the new technology and takes over as the leading country.

The ideas in Chapter 2 are similar in spirit to the idea of the 'big push' dating back to Rosenstein-Rodan (1943) and more recently developed in Murphy, Shleifer and Vishny (1989). (See Matsuyama (1995) for a survey of these and related papers). In Murphy et al (1989) the big push is associated with multiple equilibria arising from pecuniary externalities generated by imperfect competition with large fixed costs. The multiplicity of equilibria is interpreted as a switch from cottage production to industrial equilibria. In Venables (1996b), multiplicity of equilibria arise from pecuniary externalities due to imperfectly competitive vertically linked industries. And the big push is associated with a switch from a low level of output to a high level of output, with a study of how trade policy can trigger the industrialisation. Similarly, in Chapter 2 the multiplicity of equilibria arise from the type of pecuniary externalities present in Venables (1996b) but the question addressed is related to the adoption of new technology. Furthermore, it investigates circumstances where the new and old technologies can co-exist.

The industrial organisation literature has also contributed to the issue of technological leapfrogging, however the focus has been on leapfrogging between firms rather than countries. Tirole (1988), Gilbert and Newberry (1982) and Reinganum (1983) consider leapfrogging between single agents. In Tirole (1988), even though there are no externalities present, it is shown that an existing monopolist has less incentive to innovate than a rival since it would be replacing itself. However, Gilbert and Newberry (1982) show that a monopolist is still likely to innovate ahead of rivals in a world of perfect certainty. And Reinganum (1983) shows that in a world of uncertainty a monopolist is unlikely to innovate ahead of potential rivals. The industrial organisation literature has also analysed the circumstances under which a new and superior technology, incompatible with the old, will be adopted. This literature is closer in spirit to Chapter 2 as it analyses cases where a new system will take over an old system. In the presence of network externalities, Arthur (1994), Church and Gandal (1993), David (1985), Farrell and Saloner (1985, 1986), and Katz and Shapiro (1986) show that the market can be locked to an inferior choice of technology.

Chapter 3 provides an empirical analyses of specialisation patterns in the manufacturing sector of European Union (EU) countries. It addresses two questions: Has specialisation increased in EU countries?; and, are specialisation patterns consistent with any of the three strands of trade theories? According to all three strands of trade theories, reducing trade costs should lead to an increase in the degree of specialisation. Since trade costs have been falling between member countries of the EU, starting in 1957 which was the beginning of its formation, we would expect that industries should become more geographically concentrated. Analysing whether specialisation has increased is one way to ascertain whether expected gains from trade have been realised. These gains arise from allocating production according to comparative advantage and thereby achieving a more efficient allocation, by enabling firms to expand production to exploit economies of scale, and from the pecuniary externalities which arise from vertically linked industries locating close to each other.

Empirical studies on specialisation patterns in Europe have produced conflicting results. Studies by Aquino (1978) and Sapir (1996) suggest that specialisation in Europe has remained constant or fallen over the period 1951 to 1992. Aquino (1978) used the standard deviation of the Balassa index on the exports of 25 manufacturing industries from 26 countries, which included 10 EU countries, and found that over the period 1951 to 1974 the extent of inter-industry specialisation in manufacturing was limited and declined over time. Sapir (1996), using the Herfindahl index on exports of 100 manufacturing industries from 4 EU countries over the period 1977 to 1992, found that specialisation remained low and moderately constant except in France which increased its level of specialisation since 1986.

Other studies suggest that there is some evidence of increasing specialisation in EU countries. Hine (1990), using the Finger-Kreinin measure on production of 29 manufacturing industries, found that inter-industry specialisation increased for all European countries in his sample, except for Ireland, over the period 1970 to 1984. Greenaway and Hine (1991), also using the Finger-Kreinin index on production of 28 manufacturing industries in 21 OECD countries, found that for the period 1970 to 1980 only 3 out of 11 EU countries in his sample increased their specialisation whereas between 1980 to 1985 all of the 11 EU countries increased their level of specialisation. Helg et al (1995), using the Gini on the production shares of each industry in total manufacturing, where manufactures are divided into 8 sub-divisions, in 12 EU countries for the period 1975 to 1985, found that specialisation increased in 8 out of the 12 countries.

The mixed results produced by the empirical literature could be due to the different variable adopted, the level of aggregation or the differences in the measures of specialisation. These empirical studies have raised a number of measurement issues. In particular, which data sources should we use, national or trade data?; which level of aggregation?; and how should we measure specialisation? In Chapter 3, I discuss these measurement issues and I propose a new index of specialisation which overcomes some of the problems inherent in existing measures.

I utilise production data to construct indices of country specialisation for each EU country and geographical concentration for each manufacturing industry, and then see how these indices evolve over time. The movements in the country specialisation indices provide a picture of whether countries have become more different from each other in their industrial structures. The geographical concentration indices provide a picture of whether particular industries have become more geographically concentrated. I show that there is some evidence of increasing specialisation in the EU countries and increasing geographical concentration over the period 1976 to 1990. Brulhart and Tortensson (1996), in a study of 18 industries in 11 EU countries, also find evidence of increasing geographical concentration between 1980 and 1990.

Similar issues have been taken up with respect to geographical concentration of industries in the United States. Ellison and Glaeser (1994) propose a 'dartboard approach' to measuring geographic concentration of industries. They compare the actual level of geographical concentration to one that would occur if firms were to choose their locations by throwing darts at a map. This avoids the problem of industries showing high levels of concentration just because they only have a few plants in operation. This problem of 'random agglomeration' does not appear in my data set since all industries have positive outputs in all categories over the whole sample so I do not follow Ellison and Glaeser's (1994) approach. Krugman (1991b) uses the Gini to measure geographical concentration of industries in the United States. He compares the distribution of employment in a particular industry to that of overall manufacturing. I also use the Gini, as well as the other measures proposed in the empirical studies of EU countries, and discuss the relative merits of the different measures.

The geographical concentration indices are useful for studying the characteristics of the industries which have become more concentrated thereby enabling us to determine whether the specialisation patterns are consistent with any of the three stands of trade theories. I show that there is some support for the new trade theories based on scale economies and the new economic geography theories based on vertically linked industries, but only weak support for the Classical Heckscher-Ohlin theory which predicts that each country will specialise in industries which are intensive in the factors which it is abundantly endowed.

Kim (1996) presents a similar study of the determinants of geographical concentration in the United States using the Gini. He finds support for the Heckscher-Ohlin theory and the new trade theories but does not test for the new economic geography theory. The support the study claims for the Heckscher-Ohlin theory is questionable. The explanatory variable used in Kim (1996) to test for the Heckscher-Ohlin theory is a measure of raw material intensity and is defined as the cost of raw materials divided by value added. But the Heckscher-Ohlin theory does not claim that resource intensive industries will be more geographically concentrated than other factor intensive industries. Instead, it predicts that countries will specialise in industries which are intensive in the factors which they are relatively abundant. Taking this into account, I construct a variable which is the deviation of factor intensities from the mean. Those industries which differ a lot from the mean should be the most geographically concentrated if specialisation is as predicted by the Heckscher-Ohlin theory. However it is not surprising that I only find weak support for the Heckscher-Ohlin theory since the European countries in my sample are very similar in terms of their relative factor endowments. See Leamer and Levinsohn (1995) for a review of studies which test the Heckscher-Ohlin theory.

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[2] Leamer and Levinsohn (1995) argue that a full test of the Heckscher-Ohlin theory should include measures of factor endowments. We do not follow this approach as the main focus is to analyse which industries are the most geographically concentrated.

CHAPTER 1

INTER-INDUSTRY TRADE IN MANUFACTURES: DOES COUNTRY SIZE MATTER?

Nearly half of world trade takes place between industrialised countries, with a significant proportion in manufactures. Many of these countries are similar in terms of their relative factor endowments, technologies and tastes. What is the basis of this trade? Classical trade theory sees little basis for trade between similar countries - it postulates that countries trade to take advantage of their differences. The 'new trade theory' literature shows that scale economies, product differentiation and imperfect competition can generate intra-industry trade between identical countries. (See, for examples, Brander and Krugman (1983), Ethier (1979, 1982) and Krugman (1979)). The 'new economic geography' literature shows that inter-industry trade can take place between countries which are identical or only differ in size. (See Krugman (1991a), Krugman and Venables (1995) and Venables (1996b)). So the new trade theories offer an explanation of two-way trade between identical countries and the new economic geography theories offer an explanation of why there is inter-industry trade between identical countries where manufactures are exchanged for goods from another sector. But what is the basis of inter-industry trade within the manufacturing sector between similar countries?

The purpose of this Chapter is to analyse whether country size alone can be a basis of inter-industry trade within the manufacturing sector and to determine the relationship between the size of a country and the characteristics of the goods it produces and trades. Even though industrialised countries may be similar in terms of factor endowments, technologies and tastes, they certainly differ in size. To focus on the role of size, I assume that the countries are the same in every other respect.

The model I present builds on Krugman (1980), where he demonstrates two results. The first result states that if countries are identical in all respects except size, with other things equal, the large country will have a higher wage. Firms prefer to locate in only one location to save on transport costs and if production costs were the same in each country firms would prefer to locate where demand is the largest to save on transport costs. To maintain labour market equilibrium, the smaller country must offset its locational disadvantage by offering a wage differential. The second result states that each country will be a net exporter of goods it has the relatively larger domestic market - the 'home market' effect. He assumes that both countries are of equal size with two imperfectly competitive industries and consumers in each country have different tastes. So each industry will concentrate in the country which has the highest demand for its products and the country becomes a net exporter of goods from that industry. Inter-industry trade within the manufacturing sector is driven by differences in consumer tastes. (Jones (1970) also considers how different consumer tastes affect the pattern of trade).

I abandon Krugman's (1980) assumption of different consumer tastes and allow the two imperfectly competitive industries to be different. The industries may differ in terms of relative factor intensities, the level of trade costs and demand elasticities. I present a general equilibrium model in which there are two countries which are endowed with identical capital to labour ratios, but different in absolute levels, have the same technology in two imperfectly competitive industries, and whose consumers have identical tastes. The model has positive trade costs, perfect capital mobility and labour mobile only within each country.[1] The forces present in Krugman (1980) and also in Krugman and Venables (1990) and Krugman (1991a) are critical in my model. There is a 'market access' effect which attracts firms to the large market - Krugman's (1980) home market effect; and a 'production cost' effect which attracts firms to the small market due to the lower wage there. The pattern of specialisation and trade is determined by the tension between these two effects. And the relative strength of these two forces depends on how the two industries differ.

When industries differ with respect to factor intensities, the large country is a net exporter of capital intensive goods and the small country is a net exporter of labour intensive goods, with capital flowing from the small country to the large country. In Markusen (1983) factor movements and commodity trade are also complements. When industries differ with respect to transport cost or demand elasticities, there are no capital movements. Even though the endowments of capital to labour remain the same there is inter-industry trade between the two countries with the large country a net exporter of high transport cost goods and the small country a net exporter of low transport cost goods. When industries differ with respect to demand elasticities the large country has positive net exports of high elasticity goods when integration levels are close to autarky or free trade levels; and it is a net importer of high elasticity goods at intermediate levels of integration.

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[1] This is intended as a broad characterisation of the situation within the expanding European Union, or between the US and Canada. Note that in most industrialised countries labour mobility is subject to tight restrictions; within the European Union, even though labour is allowed to move, in practice, labour is prone to be culturally tied to its origins. In contrast, capital mobility is predominant among industrialised countries.

This Chapter is organised as follows. Section 1 sets out the formal model. Section 2 solves for the equilibrium of the model. Section 3 determines the production and trade patterns for each country. Section 4 concludes. All the proofs are contained in Appendix 1 of this Chapter and the parameter values of the simulations are in Appendix 2 of this Chapter.

1. THE MODEL

The model is based on Krugman (1980). It is a general equilibrium model with two countries, two imperfectly competitive industries employing two factors of production. The two countries, which we refer to as home and foreign, are identical in every respect except in size, with the home country larger than the foreign country. More specifically, the home country is endowed with more of both factors of production compared to the foreign country. I assume that neither country has a comparative advantage in producing goods: both countries are endowed with equal capital to labour ratios; they have access to the same technology; and consumers in each country have identical homothetic preferences.

We model two industries in the manufacturing sector which employ labour, L, and capital, K, in fixed proportions.[2] Capital is perfectly mobile between the countries whereas labour can only move within the same country. Each firm can choose to locate in either country and it draws on the labour and capital available in the country in which it locates, so firms move independently of capital. The two imperfectly competitive industries are labelled by subscripts 1 and 2. The market structure is one of Chamberlinian monopolistic competition. There are

[2] The fixed proportions assumption makes it possible to solve the model analytically; this would not be possible with an alternative technology. Using numerical simulations, we found that the flavour of the results is maintained even with a Cobb-Douglas technology.

many firms in both industries, each employing increasing returns to scale technology and producing differentiated goods. The two industries can differ in three respects: relative factor intensities, level of transport costs and elasticity of demand.

We specify the equations of the model for the home country and note that the same equations hold for the foreign country. (A superscript * denotes a foreign variable).

Define income, Y, as:

$$Y=wL+rK \qquad r=r^*=1 \tag{1}$$

where w is the price of labour; r is the price of capital which is equal in the two countries by our assumption of perfect mobility and used as the numeraire. Assume that capital income is consumed where it is initially endowed.[3] Relative factor endowments are equal, $k=K/L=K^*/L^*$, to abstract from comparative advantage considerations. Hence:

$$Y=(k+w)L \ ; \quad Y^*=(k+w^*)L^* \tag{2}$$

The aggregate utility function, U, for the representative consumer is Cobb-Douglas, with exponents a and 1-a.

[3] Allowing capital income to move with capital does not change the direction of trade but it does complicate the analysis. The effects of relaxing this assumption are discussed in section 3.

$$U=C_1^{a}C_2^{1-a} \tag{3}$$

where C_1 denotes aggregate consumption of industry 1 goods produced in both countries and C_2 denotes aggregate consumption of industry 2 goods produced in both countries. One can think of C_1 and C_2 as quantity indices or sub-utility functions, which are defined below. Assume that preferences are separable, that is the marginal rate of substitution between any pair of industry 1 goods does not depend on C_2 and the marginal rate of substitution between any pair of industry 2 goods does not depend on C_1; and the sub-utility functions are homothetic. These assumptions ensure that the use of two stage budgeting when solving the consumers' utility maximisation problem is efficient. We assume that consumers have Dixit-Stiglitz preferences, hence there is a taste for variety. The quantity index for industry 1 is:

$$C_1=\left[\sum_{i}^{n_1} c_{1i}^{\frac{\sigma_1-1}{\sigma_1}}+\sum_{j}^{n_1^*}(m_{1j}/\tau)^{\frac{\sigma_1-1}{\sigma_1}}\right]^{\frac{\sigma_1}{\sigma_1-1}} \tag{4}$$

where n_1 is the number of firms producing industry 1 goods, located in the home country; and n_1^* is the number of firms producing industry 1 goods, located in the foreign country. c_{1i} is consumption in the home country of industry 1 good i produced in the home country and (m_{1j}/τ) is the amount consumed in the home country of industry 1 good j produced in the foreign country. The trade costs[4] are modelled as Samuelsonian iceberg transportation costs with $\tau_1 \geq 1$. In order to deliver one unit of any good from one country to another, τ_1 units must be

[4] The trade costs are intended to reflect the cost of shipping, frontier formalities or government restrictions. Alternatively, they could be reinterpreted as tariffs.

shipped as only a fraction $1/\tau_1$ arrives, while $1-(1/\tau_1)$ melts in transit. If $\tau_1=1$ there is free trade in industry 1 goods and if $\tau_1=\infty$ there is no trade in industry 1 goods. σ_1 is the elasticity of substitution between any pair of differentiated goods in industry 1. With $1 < \sigma_1 < \infty$, the sub-utility function is concave hence all consumers want to consume some of each variety.

Dual to industry 1's quantity index, the price index, P_1, is:

$$P_1=\left[\sum_i^{n_1} p_{1i}^{1-\sigma_1}+\sum_j^{n_1^*}(p_{1j}^*\tau_1)^{1-\sigma_1}\right]^{\frac{1}{1-\sigma_1}} \tag{5}$$

where p_{1i} is the producer price set by firm i in industry 1 of the home country and p_{1j}^* is the producer price set by firm j in industry 1 of the foreign country.

Now consider the production technology. The technology of firms in both industries exhibits increasing returns to scale. We assume that the economies of scale are relatively small so that the number of varieties is large enough to make oligopolistic interactions negligible. This means that the pricing policy of each firm has almost no effect on the marginal utility of income. The production function for each variety i in industry 1 is:

$$\alpha+\beta X_{1i}=\min\left(\frac{1}{\gamma_1}L_{1i},\frac{1}{\delta_1}K_{1i}\right) \tag{6}$$

where α represents the fixed cost[5] of production, giving rise to increasing returns

[5] Having industry specific fixed costs does not add anything to the analysis. A different fixed cost changes the scale of production but does not influence the direction of net trade. Hence, for simplicity α is the same for both industries.

to scale, β is marginal cost and X_{1i} is the quantity of industry 1 goods produced by firm i in the home country. All firms in the industry share the same fixed proportions technology. The right hand side of equation (6) represents the composite demand for factors by firm i in industry 1. To increase production of X_{1i} by one unit, firm i must use an additional $\beta\gamma_1$ units of labour and $\beta\delta_1$ units of capital irrespective of input prices, since the elasticity of substitution between the two factors is zero.

The cost function for each firm in industry 1, $b_{1i}(.)$, dual to the production function is:

$$b_{1i}(w,1,X_{1i})=(\gamma_1 w+\delta_1)(\alpha+\beta X_{1i}) \tag{7}$$

Profit for each firm in industry 1, Π_{1i}, is total revenue less total costs:

$$\Pi_{1i}=p_{1i}X_{1i}-(\gamma_1 w+\delta_1)(\alpha+\beta X_{1i}) \tag{8}$$

We assume there is free entry and exit. With a large number of symmetric firms in each industry profits for each firm will be zero.

By changing the subscripts in equations (4) to (8) from 1 to 2, we have a description of industry 2. Industry 2 can differ from industry 1 in three respects and we will consider each case separately when we determine the production and trade patterns of the two countries. For concreteness we assume that industry 1 is relatively more labour intensive, $\gamma_1/\delta_1 \geq \gamma_2/\delta_2$; transport costs are higher in industry 1, $\tau_1 \geq \tau_2$; and elasticity of demand faced by firms in industry 1 is higher, $\sigma_1 \geq \sigma_2$.

We assume factor markets are perfectly competitive and factors fully employed.

2. EQUILIBRIUM OF THE MODEL

Having set out the definitions and the assumptions of the model, we can begin to solve for equilibrium. We do this in four stages. First, we solve the representative consumer's utility maximisation problem. Second, we solve the ith firm's profit maximisation problem in both industries to derive the producer prices. Using the free entry and exit condition, we derive the number of units each firm must produce to cover fixed cost. Third, we determine factor market clearing conditions and product market clearing in each industry. Finally, with some substitutions, we derive the equilibrium conditions which simultaneously solve for income, wages, and the number of firms in each industry for both countries.

First, consider the representative consumer's behaviour. Since the Cobb-Douglas preferences, U, are separable and the sub-utility functions, C_1 and C_2, are homothetic, we can derive demand functions using two stage budgeting. In stage one, the consumer can allocate expenditure between the two groups of goods without knowledge of individual prices of each good; all that is required are the price indices. Maximisation of the Cobb-Douglas utility function (equation (3)) subject to the budget constraint (equation (2)) allocates expenditure between the two industries as follows:

$$P_1C_1=aY \tag{9}$$

$$P_2C_2=(1-a)Y \tag{10}$$

In stage 2, the consumer maximises the sub-utility function (equation (4)) subject to the budget constraint (equation (9)) to derive demand functions for each industry 1 good produced in the home country and the foreign country.

$$c_{1i}=p_{1i}^{-\sigma_1}P_1^{\sigma_1-1}aY \tag{11}$$

$$m_{1j}=\tau_1^{1-\sigma_1}(p_1^{*-\sigma_1}P_1^{\sigma_1-1}aY) \tag{12}$$

The demand functions for industry 2 goods are derived in the same way, by maximising the sub-utility function C_2 subject to the budget constraint (equation (10)).

Second, consider firm i's behaviour in industry 1. Each firm i chooses a variety and its pricing so as to maximise profits, taking as given the variety choice and pricing strategy of the other firms in the industry. Production of each variety will only be undertaken by one firm since a potential entrant can always do better by introducing a new product variety than by sharing in the production of an existing product type.[6]

Maximising profits with respect to quantity gives the usual marginal revenue equals marginal cost condition.

$$\frac{\partial \Pi_{1i}}{\partial X_{1i}}=0 \Rightarrow p_{1i}=(\gamma_1 w+\delta_1)\beta\left(\frac{\sigma_1}{\sigma_1-1}\right) \tag{13}$$

Price is a constant mark-up over marginal cost. Given identical technology, all firms in the industry set the same price therefore we can drop the i subscript. The price of labour, w, is the same for all firms located in the home country

[6] Even though a firm would be indifferent between mimicking an existing variety produced abroad and producing a completely new variety in autarky, since it is costless to differentiate a product all firms will produce distinct varieties when we allow trade.

since labour is mobile between industries within the same country. However, the price of labour in the home country need not be equal to the price of labour in the foreign country, w^*, since labour is internationally immobile.

Imposing the free entry and exit condition, by setting profits equal to zero, determines the quantity of output required to just cover fixed cost.

$$\Pi_{1i}=0 \Rightarrow X_{1i}=\frac{\alpha(\sigma_1-1)}{\beta} \tag{14}$$

Again, this is the same for all firms in the industry so we drop the subscript i. Output is fixed and independent of price and the number of firms. This is a direct consequence of the Dixit-Stiglitz preferences. A constant elasticity of substitution leads to constant mark-up pricing hence each firm requires a fixed amount of production to cover fixed costs. The higher is the fixed cost, α, the higher is the amount of output required; the lower is the elasticity of demand, σ, the higher is the mark-up on price therefore the smaller is the amount of output required; and the higher is the marginal cost, β, the higher is the price and therefore the lower is the amount of output required. The price and output level for industry 2 goods can be derived in the same way.

Third, consider equilibrium in each market. Factor market equilibrium requires that the sum of demands for each factor equals the supply of that factor.

$$n_1(\alpha+\beta X_1)\gamma_1+n_2(\alpha+\beta X_2)\gamma_2=L \tag{15}$$

By Walras law, we don't need to specify the equilibrium condition in the world capital market.

Product market equilibrium requires that demand equals supply for each good in both industries.

$$X_i = c_i + m_i^* \quad i = 1,2. \tag{16}$$

We can reduce the model to four equations for each country which simultaneously solve for Y, Y^*, w, w^*, n_1, n_1^*, n_2, n_2^*. By substituting equations (14) and the symmetric equation for industry 2 into (15), we can rewrite the labour market clearing condition as:

$$n_1 \alpha \sigma_1 \gamma_1 + n_2 \alpha \sigma_2 \gamma_2 = L \tag{17}$$

Substituting equations (5), (11), (12), (13) and (14) into (16), for i=1, we have the equilibrium zero profit condition (or equilibrium product market condition) for industry 1 firms:

$$\frac{\alpha(\sigma_1-1)}{\beta} = \frac{(\sigma_1-1)}{\beta\sigma_1}(\gamma_1 w+\delta_1)^{-\sigma_1}\{[n_1(\gamma_1 w+\delta_1)^{1-\sigma_1}+n_1^*(\gamma_1 w^*+\delta_1)^{1-\sigma_1}\tau_1^{1-\sigma_1}]^{-1}aY$$
$$+\tau_1^{1-\sigma_1}[n_1(\gamma_1 w+\delta_1)^{1-\sigma_1}\tau_1^{1-\sigma_1}+n_1^*(\gamma_1 w^*+\delta_1)^{1-\sigma_1}]^{-1}aY^*\} \tag{18}$$

Similarly, by substituting symmetric equations for firms in industry 2 into equation (16),for i=2, we have the equilibrium zero profit condition for industry 2 firms:

$$\frac{\alpha(\sigma_2-1)}{\beta}=\frac{(\sigma_2-1)}{\beta\sigma_2}(\gamma_2 w+\delta_2)^{-\sigma_2}\{[n_2(\gamma_2 w+\delta_2)^{1-\sigma_2}+n_2^*(\gamma_2 w^*+\delta_2)^{1-\sigma_2}\tau_2^{1-\sigma_2}]^{-1}aY \tag{19}$$

$$+\tau_2^{1-\sigma_2}[n_2(\gamma_2 w+\delta_2)^{1-\sigma_2}\tau_2^{1-\sigma_2}+n_2^*(\gamma_2 w^*+\delta_2)^{1-\sigma_2}]^{-1}aY^*\}$$

Equations (2), (17), (18) and (19) together with equations for the foreign country provide all the information we require to analyze the effect of integration on the production and trade patterns of each country.

3. PRODUCTION AND NET TRADE PATTERNS

I will begin the analysis by determining the relative production patterns of the two countries in autarky, $\tau=\infty$, and then compare this to the production patterns when we allow trade, $\infty < \tau \leq 1$. We define the relative production patterns in the home country and the foreign country respectively as:

$$\frac{n_1 X_1}{n_2 X_2}\ ,\ \frac{n_1^* X_1^*}{n_2^* X_2^*} \tag{20}$$

Since the quantity supplied by each firm in each industry is constant, independent of price, the number of firms and the degree of integration, τ, this problem reduces to finding the relative number of firms in each country as a function of transport costs.

From the relative production patterns it is easy to deduce the direction of net trade. With Dixit-Stiglitz preferences, consumers demand all varieties so countries engage in intra-industry trade when τ is less than infinity. If the relative number of firms in the home country, n_1/n_2, is greater than the relative number of firms in the foreign country, n_1^*/n_2^*, then the home country has positive net exports of industry 1 goods and negative net exports of industry 2 goods. Net exports in each industry are defined as total exports less total imports. Hence, the home country's net exports are:

$$n_j m_j^* - n_j^* m_j \,, \qquad j=1,2. \tag{21}$$

where $n_j m_j^*$ is the amount of industry j goods the consumers in the foreign country demand which is greater than the amount they consume since some goods melt in transit.

3 (a) Autarky and free trade

Note that none of the three industry characteristics which we allow to vary has an influence on equilibrium either in autarky or free trade.

Proposition 1: In autarky, the relative number of firms in the small country is equal to the relative number of firms in the large country, and factor prices are equal across the countries. In free trade, the relative number of firms in each country is indeterminate and factor prices are equal across the countries.

More formally,

(a) if $\tau=\infty$, then $w^*/w=1$, $n_1^*/n_2^* = n_1/n_2$; and

(b) if $\tau=1$, then $w^*/w=1$, n_1^*/n_2^* and n_1/n_2 are indeterminate.

Under autarky, each country is completely separate and the home country is just a scale expansion of the foreign country. Even though firms enjoy economies of scale, each firm in each industry produces the same amount of output in equilibrium, so if the home country is twice as large as the foreign country, it will have twice as many firms in both industries. To see that the first part of proposition 1 is true, let us double all the quantities in one country at unchanged prices and check that this is an equilibrium. From the labour market clearing condition, equation (17), it is clear that labour demand is homogenous of degree one in the number of firms; capital demand is also homogenous of degree one in the number of firms. If the quantities of labour and capital are doubled, from equation (2) we see that income also doubles. Since consumers' preferences are assumed to be Cobb-Douglas, the share of expenditure on each industry's goods is constant. In the product market equilibrium conditions, equations (18) and (19), if we set $\tau=\infty$; substitute in for income from equation (2); and double the quantities of capital, labour and the number of firms, we see the wage is unchanged. Recall that the price of capital is the numeraire set equal to 1 and note that the wage is the nominal wage in terms of the numeraire and not the real wage so that with equal factor prices, capital has no incentive to move in autarky even though it is mobile.[7]

The result under free trade follows from the factor price equalisation theorem. Since both countries have identical technologies, free trade in goods will ensure that the prices of goods in the two countries are equal. The price of capital is set in the world capital market whereas the price of labour is set internally. Since the price of goods is a function of the wage and rent (see equation (13)), if prices are equal it follows that wages must also be equal. With free trade, one can think of the two countries being like one big country, hence the location of firms is immaterial.

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[7] Note that the utility of each consumer in the large country is higher than in the small country since utility is increasing in the number of product varieties. Equilibrium is not affected by these utility differences since labour is immobile across countries.

3 (b) Partial Integration

Integration of the two countries leads to a divergence in production patterns so countries can attain a degree of specialisation. The driving force of the diverging industrial structures is the tension between the market access effect and the production cost effect. Let us examine each effect more closely.

First, consider the market access effect. Compared to the distribution of firms in autarky more firms will want to locate in the large country when we allow trade, for all $\infty < \tau < 1$, if factor prices are equal across the two countries, $w^*=w$ and $r^*=r$. To cover fixed costs, each firm must produce a given amount of output through domestic sales and exports. Reducing transport costs from the autarky level, $\tau=\infty$, to some finite level, $\tau > 1$, has two effects at the initial $w^*=w$. (i) The 'import competition' effect: a fall in τ reduces the price index due to the extra firms competing for demand. (See equation (5)). This leads to a fall in domestic demand for domestically produced goods in each country. (See equation (11)). The price index falls by more in the small country than in the large country since firms in the small country are exposed to more import competition compared to firms in the large country. (ii) The 'export growth' effect: a fall in τ leads to an increase in exports to each country. The absolute demand for goods produced abroad increases more in the large country than in the small country. (See equation (12)). As a result firms in the small country gain more in export sales than firms in the large country since they have access to a relatively larger market. However it is the import competition effect which dominates since sales in the domestic market are more significant than exports for any positive level of transport costs. Firms in the small market find that the gain in exports does not offset the sales lost in the domestic market so that the amount of output they can sell is insufficient to cover fixed costs and this leads to the exit of some firms. The reverse is true in the large country, so there is entry. The net effect is that, compared to the autarky distribution of firms, more firms would locate in the large country if factor prices were equal.[8]

Now, consider the production cost effect. If firms were to relocate from the small country to the large country, the demand for factors in the large country would increase. An increase in the demand for capital in the large country results in capital flowing from the small country to the large country since capital is freely mobile between the two countries. In contrast, an increase in the demand for labour in the large country pushes up wages in the large country relative to the small country since labour is not mobile between the two countries, that is w^*/w falls. Relative wages must adjust to maintain labour market equilibrium. This is what I refer to as the production cost effect.

A lower w^*/w offsets the locational advantage of the large country. The relative strengths of the market access effect and the production cost effect will depend on how the two industries differ. We allow the two industries to differ in three respects: relative factor intensities, level of transport costs and demand elasticities. We consider each case in turn.

(i) Different relative factor intensities

Suppose that industry 1 is more labour intensive than industry 2, but the same in all other respects. To produce one unit of output, industry 1 requires relatively more labour than industry 2. If the two countries are partially integrated, which country will be relatively more specialised in the production of the labour intensive goods; which country will be a net exporter of labour intensive goods;

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[8] Setting $w^*/w=1$ in equation (A2) in Appendix 1, we find that $d(n_i^*/n_i)/d\tau > 0$, evaluated at $\tau\rightarrow\infty$.

and in which direction will capital flow?

Proposition 2: For intermediate values of transport costs, the small country is relatively more specialised in the production of labour intensive goods, and the large country is relatively more specialised in the production of capital intensive goods. Hence, the small country is a net exporter of labour intensive goods and the large country is a net exporter of capital intensive goods.

More formally, when $L^*/L=\lambda<1$ and $\sigma_1=\sigma_2=\sigma$, $\tau_1=\tau_2=\tau$, $\gamma_1/\delta_1 > \gamma_2/\delta_2$, if $1 < \tau < \infty$, then $w^*/w<1$ and $n_1^*/n_2^* > n_1/n_2$.

Corollary 1

For intermediate values of transport costs, the large country is a net importer of capital.

The proof of proposition 2 is in two steps. First, I show that the wage in the large country is higher than in the small country for all intermediate levels of integration, $1<\tau<\infty$. If wages were equal, more of both industries' firms would locate in the large country compared to the autarky distribution of firms. (See equations (A5) and (A6)). But this is not possible if factor market equilibrium is to hold. The wage in the small country must be lower than in the large country to attract firms back to the small country. In the second step, we suppose that it is possible to have industry specific wages. What will these wages be to maintain the autarky distribution of firms? I show that the relative wage in the labour intensive industry, w_1^*/w_1, is greater than in the capital intensive industry, w_2^*/w_2. (See equations (A9) and (A10)). But in equilibrium, the wage in each industry within a country must be equal since labour is mobile between industries within each country. The equilibrium wage ratio will lie somewhere in between the two industry specific wage ratios. Since the equilibrium wage is less than w_1^*/w_1, more industry 1 firms will locate in the small country compared to the autarky distribution; and by applying the same argument to industry 2, we establish that more capital intensive firms will locate in the large country. To prove the corollary, I show that the demand for capital in the large country is greater than its initial endowment and the demand for capital in the small country is less than its initial endowment. (See equations (A11) and (A12)).

Let us turn to the intuition behind the result. Reducing transport costs from the autarky level, $\tau=\infty$, to some finite level, $\tau>1$, induces more firms to relocate to the large country, at the initial factor prices. To maintain factor market equilibrium, capital flows from the small to the large country and w^*/w falls, so the wage to rental ratio in the large country is higher than in the small country. Labour intensive firms are more attracted to the country with the low wage to rental ratio whereas capital intensive firms are more attracted to the country with the high wage to rental ratio. When industries only differ with respect to factor intensities, the force of the market access effect, attracting firms to the large country, is the same for firms from each industry as saving on transport costs is equally important for all firms. In contrast, the production cost effect makes the small country relatively more attractive to the labour intensive firms. Consequently, relatively more industry 1 firms locate in the small country and relatively more industry 2 firms locate in the large country, compared to the distribution of firms under autarky.

Determining the countries' trade patterns is straightforward now that we know the production pattern of each country. Since the large country produces relatively more capital intensive goods, it becomes a net exporter of capital intensive goods; and the small country, which produces relatively more labour intensive goods, becomes a net exporter of labour intensive goods. As industry 2 firms require relatively more capital to produce a unit of output compared to industry 1 firms, in equilibrium the large country ends up with more capital than it was initially endowed with. So, capital flows from the small country to the large country.

To see whether specialisation increases with the degree of integration we turn to numerical simulations of the model, which are graphed in Figures 1, 2, 3 and 4. Figure 1 suggests a U shaped relationship between relative wages and transport costs (Venables and Krugman (1990) is the first paper to show this U shaped relationship); Figure 2 indicates a monotonic relationship between the relative number of firms in each country and transport costs. For the particular parameter values specified, at integration levels close to the free trade level, as $\tau \rightarrow 1$, the foreign country is completely specialised in the production of labour intensive goods so $n_2^*=0$. The higher the degree of integration, the higher the degree of specialisation. Whether there is complete specialisation depends on parameter values, in particular on the difference in factor intensities and the size of the countries. Figure 3 graphs the home country's net exports as a function of transport costs, indicating that net exports are increasing in the degree of integration and Figure 4 shows that capital flows are also increasing in the degree of integration.

When transport costs fall from the autarky level the wage gap between the two countries increases due to the market access effect. This provides industry 2 firms with a relatively greater incentive to locate in the large country and industry 1 firms to locate in the small country. After some critical level of transport costs the market access effect starts to become less important relative to production cost considerations. Hence the wage gap starts to close. w^*/w starts to increase but is still less than 1. With low levels of transport costs industry 1 firms require a smaller wage differential to be attracted to the small country and similarly for industry 2 firms to be attracted to the large country.

Simulating the model for firms with a Cobb-Douglas technology suggests a similar pattern of production and trade as for firms with a Leontief technology. The intuition is the same for firms with either technology. The market access effect attracts more firms to the large country compared to the autarky distribution, pushing up the wage to rental ratio in the large country. A firm with Cobb-Douglas technology can substitute capital for labour, therefore the increase in demand for labour in the large country is not as high as it would be if firms had fixed proportions technology. So the wage gap between the two countries is not as high. If firms had Cobb-Douglas technology the wage relativity function would lie above that in Figure 1, with the end points equal at $w^*/w=1$. But the incentive for a capital intensive firm to locate in the large country and substitute capital for labour is stronger than for a labour intensive firm since it faces a higher technical rate of substitution of capital for labour. So, the large country would still be relatively more specialised in the production of capital intensive goods and have positive net exports of capital intensive goods.

It is instructive to see how the results depend on the assumptions about capital. How would the results be affected if capital income moved with capital? The incentive for firms to locate in the large country would be even greater than if capital income were consumed where it was endowed. The market access and production cost effects work in the same way as before. The difference here is that as more firms locate in the large country, the large country becomes even larger since the capital income in the large country is increasing. This makes the market access effect even stronger so the wage relativity must be higher to attract firms to the small country to maintain labour market equilibrium.

What happens if capital is immobile between countries? Now an increase in demand for factors in the large country pushes up the price of labour and capital. With equal levels of transport costs and demand elasticities, the market access effect is equally powerful in both industries. In equilibrium, the wage to rental ratios in both countries are equal and the distribution of firms is the same as under autarky so there is no specialisation and no inter-industry trade.

It is interesting to compare the pattern of production and trade arising in this model with that in the Heckscher-Ohlin model. The standard assumptions in the Heckscher-Ohlin model are: the endowments of capital to labour in each country are unequal; factors can only move within a country; goods are freely traded; and firms are perfectly competitive. According to the Heckscher-Ohlin theorem, the country that is initially endowed with the higher capital to labour ratio will specialise and export the good which is capital intensive. I initially endow each country with equal capital to labour ratios and after allowing trade, the large country ends up with a higher capital to labour ratio than the small country. Then the pattern of trade is consistent with the Heckscher-Ohlin theorem but in this paper the comparative advantage arises endogenously rather than being assumed. If we add trade costs on goods and allow capital to be freely mobile in the Heckscher-Ohlin model, to match the assumptions of my model, allowing trade results in capital flowing to equalise capital to labour ratios and there would be no trade in goods.

(ii) Different levels of transport costs

Now consider the case where the two industries are identical except that the level of transport costs are higher for industry 1 goods than for industry 2 goods, $\tau_1 > \tau_2$. Imagine, for instance, that industry 1 goods are bulkier to transport. Which country will be relatively more specialised in the production of 'high' transport cost goods?

Proposition 3: For intermediate values of transport costs, the small country is relatively more specialised in the production of 'low' transport cost goods, and the large country is relatively more specialised in the production of 'high' transport cost goods. Hence, the small country is a net exporter of 'low' transport cost goods and the large country is a net exporter of 'high' transport cost goods.

More formally, when $L^*/L=\lambda<1$ and $\gamma_1/\delta_1=\gamma_2/\delta_2$, $\sigma_1=\sigma_2=\sigma$, and $\tau_1>\tau_2$, if $1 < \tau_1 < \infty$, and $1 < \tau_2 < \infty$, then $w^*/w<1$ and $n_1^*/n_2^* < n_1/n_2$.

To prove proposition 3, I show that the wage relativity required to maintain the autarky distribution of firms is higher in the 'low' transport cost industry than in the 'high' transport cost industry, $w_2^*/w_2>w_1^*/w_1$, for $1 < \tau < \infty$. (See equations (A13), (A14) and (A15)). The equilibrium wage ratio will lie somewhere in between. Since the equilibrium wage ratio is less than w_2^*/w_2, more industry 2 firms will locate in the foreign country compared to the autarky distribution of firms; and by applying the same argument to industry 1, we establish that more 'high' transport cost firms will locate in the large country.

Again, there is a tension between the market access effect, attracting firms to the large country, and the production cost effect, attracting firms to the small country. But now it is the market access effect which plays the dominant role in determining the distribution of firms. Clearly, the incentive to locate in the large country to minimise transport costs is stronger for the 'high' transport cost firms than for the 'low' transport cost firms. But the incentive to locate in the small country to take advantage of the lower wage is the same for firms from each industry since relative factor intensities are identical for all firms. So the large country is a net exporter of 'high' transport cost goods. Since firms have the same relative factor intensities there are no capital flows, so capital to labour ratios remain equal in the two countries for all levels of integration.

The numerical simulations of this case reveal that relative wages follow a similar U shaped pattern to that depicted in Figure 1; integration results in an increasingly diverging industrial structure and the relationship between the relative number of firms and transport costs is monotonic as in Figure 2 but in this example specialisation is not complete; and net exports are also monotonic in transport costs as in Figure 3.

A more interesting pattern of production and trade emerges when we allow the industries to differ with respect to more than one characteristic. Suppose that industry 1 is more labour intensive and is subject to higher trade costs than industry 2. This could represent a situation where a labour intensive industry, which has a strong union, resists trade liberalisation. The pattern of specialisation is graphed in Figure 5. At low levels of integration, when exports make up a small share of total sales, it is the production cost effect which dominates: the large country is relatively more specialised in capital intensive, low transport cost goods. After some critical τ when the countries reach a high degree of integration, since exports make up a more significant share of total sales, the market access effect dominates: the large country is relatively more specialised in labour intensive, high transport cost goods. In this example, the large country is a net importer of capital at low levels of integration and a net exporter of capital at high levels of integration.

If capital were immobile and if the two industries differed in terms of factor intensities and transport costs integration would still lead to some specialisation and net trade. Suppose that both industries had access to a Cobb-Douglas technology, to avoid problems of market clearing associated with Leontief technology, then the large country will specialise in the production of high transport goods irrespective of whether the industry is labour or capital intensive since the market access effect is stronger for high transport cost. So if industry 1 is labour intensive and subject to higher transport costs than industry 2, the large country would specialise and be a net exporter of labour intensive goods even though the endowment of capital to labour ratios is identical in both countries, and the wage to rental ratio is higher in the large country compared to the small country.

(iii) Different demand elasticities

Finally, consider the case where the two industries are identical in all respects except that industry 1 firms are subject to a higher demand elasticity than industry 2 firms, $\sigma_1 > \sigma_2$. If two countries are partially integrated, which country will be relatively more specialised in the production of the 'low' elasticity goods?

Proposition 4: At integration levels close to free trade and autarky, the small country is relatively more specialised in the production of 'low' elasticity goods, and the large country is relatively more specialised in the production of 'high' elasticity goods. Hence the small country is a net exporter of 'low' elasticity goods and the large country is a net exporter of 'high' elasticity goods.

More formally, when $L^*/L=\lambda<1$ and $\tau_1=\tau_2=\tau$, $\gamma_1/\delta_1=\gamma_2/\delta_2$, $\sigma_1>\sigma_2$, if $\tau\to\infty$ or $\tau\to 1$, then $w^*/w<1$, $n_1^*/n_2^* < n_1/n_2$.

Conjecture 1

If industries differ only with respect to demand elasticities, for some range of intermediate levels of integration, the small country produces relatively more 'high' elasticity goods compared to the large country.

To prove proposition 4, I show that the wage relativity required to maintain the autarky distribution of firms is higher in the 'low' elasticity industry than in the 'high' elasticity industry, $w_2^*/w_2 > w_1^*/w_1$, for $\tau \rightarrow \infty$ and $\tau \rightarrow 1$. (See equations (A16), (A17) and (A18)). The equilibrium wage ratio will lie somewhere in between. Since the equilibrium wage ratio is less than w_2^*/w_2 more industry 2 firms will locate in the foreign country compared to the autarky distribution of firms; and by applying the same argument to industry 1, we establish that more 'high' elasticity firms will locate in the large country. Numerical simulations indicate the pattern is reversed for intermediate levels of integration.

Whether the market access effect or production cost effect dominates in determining the distribution of firms depends on the degree of integration. 'High' elasticity firms need to produce more output than the 'low' elasticity firms in order to cover fixed costs, therefore they have a stronger incentive to make more sales. The higher is σ, the lower is the mark-up over marginal cost and hence the higher is the quantity of output required to cover fixed costs. (See equations (13) and (14)). There are two opposing forces here: (i) With positive transport costs, there is a bigger cost of locating in the small country for 'high' elasticity firms than for 'low' elasticity firms. Since consumers must pay the transport cost on imports, 'high' elasticity firms lose more on exports than 'low' elasticity firms. This market access effect provides a stronger incentive for 'high' elasticity firms to locate in the large country; (ii) As price is a mark-up on marginal cost the price set in the large country is higher than the price set by firms in the same industry in the small country since $w^*/w < 1$. 'High' elasticity firms would lose more on sales than 'low' elasticity firms by locating in the large country. This production cost difference provides a stronger incentive for 'high' elasticity firms to locate in the small country.

At integration levels close to the autarky and free trade level, where the wage difference between the two countries is not too large (see Figure 1), it is the first effect which dominates, therefore the large country produces relatively more 'high' elasticity goods. However, when the wage disparity is larger, it is the second effect which dominates. For some intermediate levels of integration, the large country produces relatively more 'low' elasticity goods. Figure 6 is suggestive of how the pattern of industrial specialisation changes with transport costs.

If industry 1 goods were costless to transport, $\tau_1 = 1$, then the small country would be relatively more specialised in the production of 'high' elasticity goods for all $1 < \tau_2 < \infty$. This is consistent with Krugman & Venables (1990) and Krugman (1991a) where the small country is a net exporter of a perfectly competitive good which is costless to transport. It is easy to see that we get this result even with two imperfectly competitive industries. If 'high' elasticity firms' goods are costless to transport, the market access effect for industry 1 does not exist, the production cost effect determines that the small country produces relatively more 'high' elastic goods.

Now that we have established the production patterns, we can deduce that at integration levels close to the autarky and free trade levels, if both types of goods are subject to transport costs, the large country is a net exporter of 'high' elasticity goods and the small country is a net exporter of 'low' elasticity goods; and the reverse trade pattern emerges for some intermediate range of integration. There will be no capital flows between the two countries as the relative factor intensities of both industries are identical.

4. CONCLUSIONS

As countries are becoming generally more open to trade across the world, incentives affecting firms' decisions on where to locate are changing. Since a large amount of trade takes place between industrialised countries, where perhaps the most noticeable differences between the countries is size, it is of interest to know whether size alone can be a basis for international specialisation and inter-industry trade. The main contribution of this Chapter is to demonstrate that this can be so and to determine the direction of inter-industry trade between two countries which only differ in size. With the insight gained from the new trade literature which shows that countries trade to take advantage of scale economies, and the geography and trade literature which shows that the large country has a higher wage than the small country, it is demonstrated that country size can be a determinant of the direction of trade flows, once there is some asymmetry between the two industries. I allow the industries to have different factor intensities, transport costs and demand elasticities.

When industries only differ with respect to factor intensities, the large country is a net exporter of capital intensive goods and the small country is a net exporter of labour intensive goods. Although the two countries are initially endowed with the same capital to labour ratios, when the countries are allowed to trade, capital has an incentive to flow to the large country. So comparative advantage arises endogenously and then the pattern of inter-industry trade is consistent with the Heckscher-Ohlin theorem.

When industries differ with respect to transport cost or demand elasticities, there are no capital movements. Even though capital to labour ratios remain the same, there is inter-industry trade between the two countries with the large country having net exports in the high transport cost goods and the small country in the low transport cost goods. When industries differ with respect to demand elasticities the pattern of trade is more complicated: the large country has positive net exports of high elasticity goods when integration levels are close to autarky or free trade levels; it is a net importer of high elasticity goods at intermediate levels of integration.

In practice industries usually differ with respect to more than one characteristic. I show that if the labour intensive industry is subject to higher trade costs than the capital intensive industry, which may be due to the presence of a strong union resisting trade liberalisation, then the large country is a net exporter of labour intensive goods at high levels of trade cost and capital flows from the large country to the small country; this pattern is reversed at a low levels of trade costs, with the large country becoming a net exporter of capital intensive goods, and capital flowing from the small country to the large country. So we also have an explanation of why countries may change their pattern of specialisation.

If capital were also immobile between the two countries, and the two industries differed in terms of factor intensities and trade costs, then integration would still lead to some degree of specialisation and inter-industry trade. If the labour intensive industry is subject to higher trade costs, the large country would specialise and be a net exporter of labour intensive goods even though the endowment of capital to labour ratios is identical in both countries, and the wage to rental ratio would be higher in the large country compared to the small country.

FIGURE 1: Relative wages

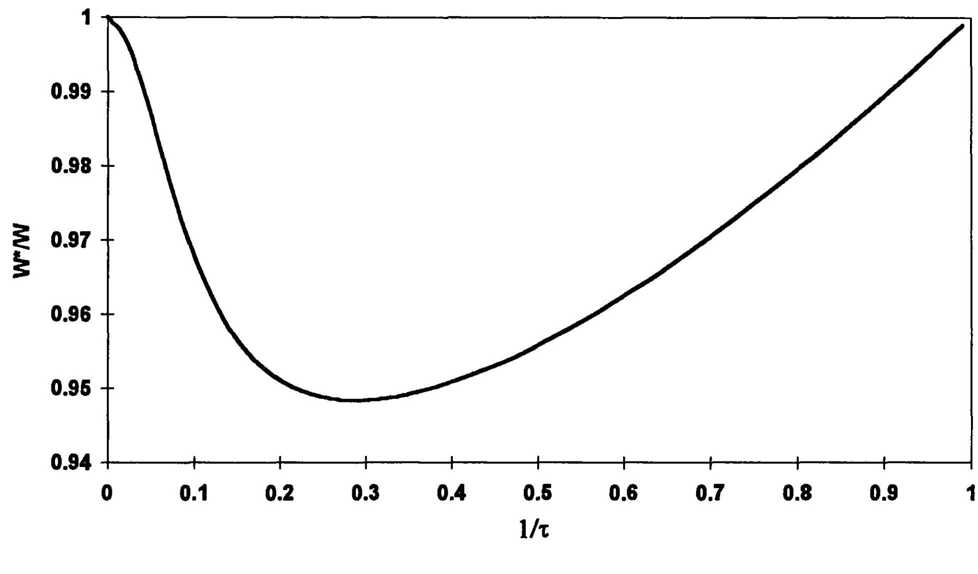


FIGURE 2: Relative number of firms
Different Factor Intensities

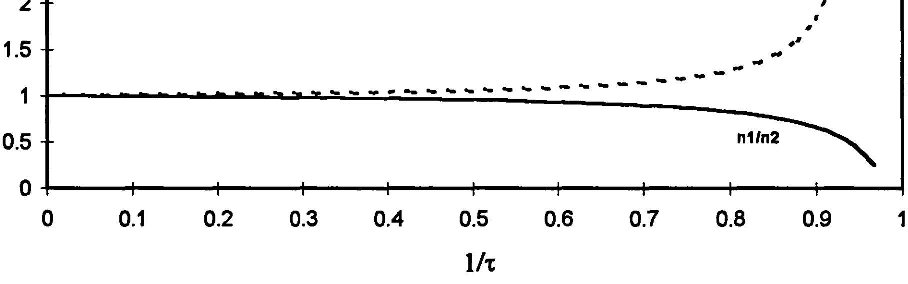


Figure 3: Home Country's Net Exports of Goods

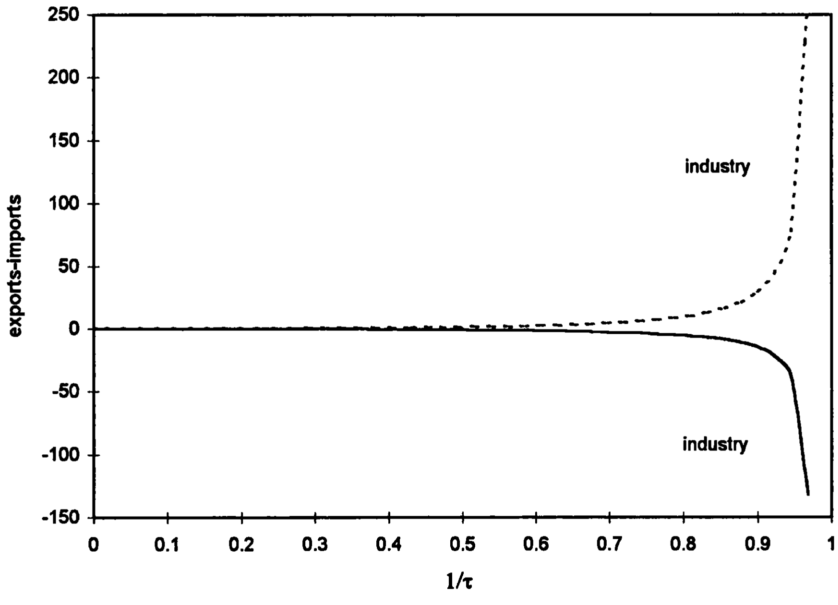


Figure 4: Home Country's Net Exports of Capital

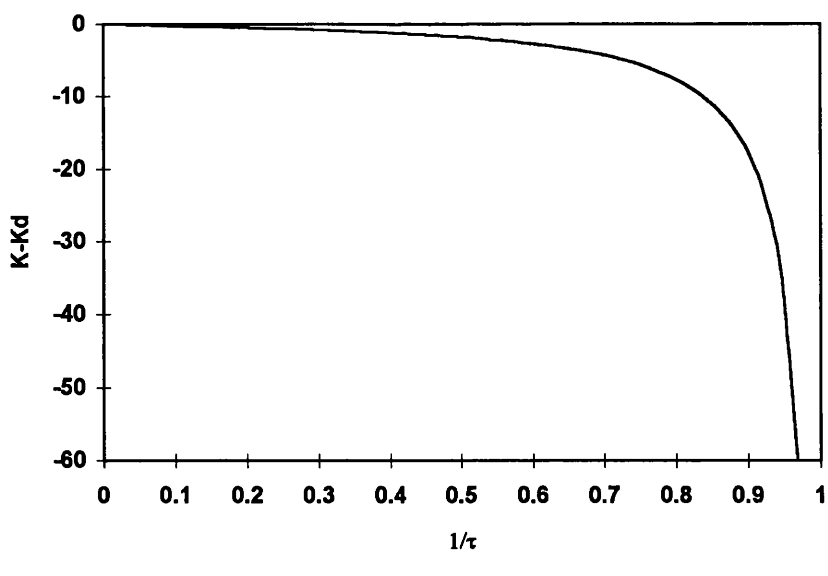


Figure 5: Relative Number of Firms
Different Factor Intensities & transport costs

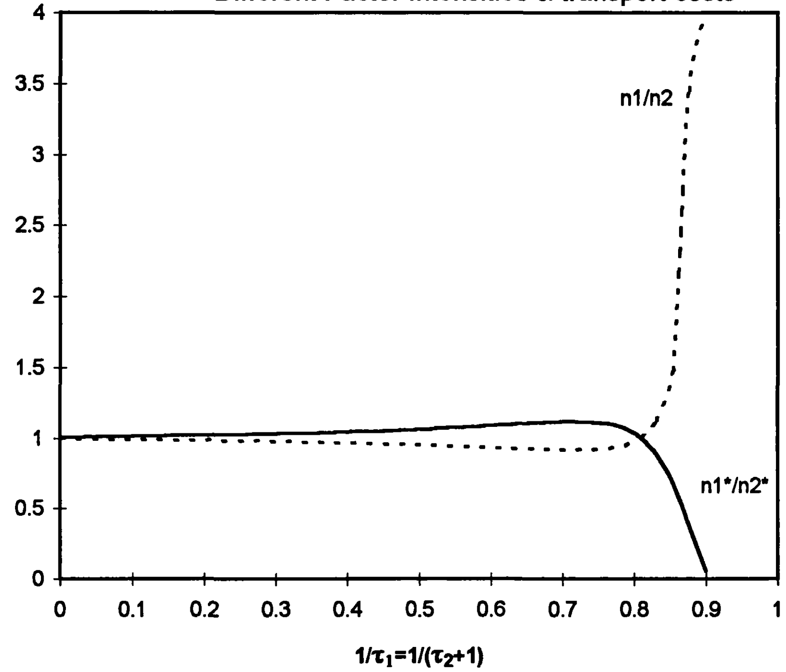
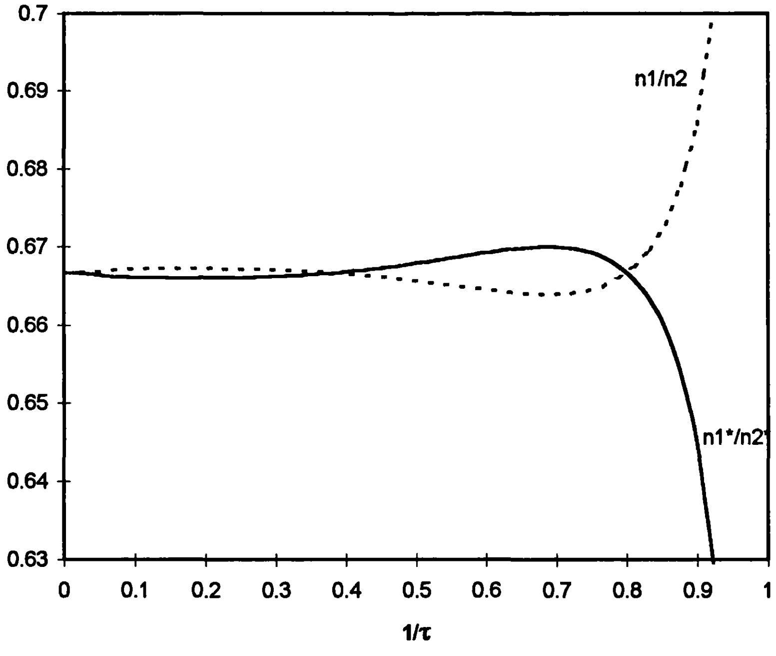


Figure 6: Relative Number of Firms
Different Demand Elasticities



APPENDIX 1

It will be useful for the proofs to rewrite the equilibrium equations. First, for convenience, define:

$$\theta_i \equiv \frac{n_i^*}{n_i} \qquad \rho_i \equiv \frac{\delta_i/\gamma_i + w^*}{\delta_i/\gamma_i + w} = \frac{MC_i^*}{MC_i} \qquad \omega \equiv \frac{k+w^*}{k+w} \qquad i=1,2. \qquad \textbf{(A1)}$$

where MC_i and MC_i^* are the marginal costs for industry i located in home and foreign respectively.

Take the ratio of the equilibrium product market conditions for industry i in the foreign country to the home country (equation 19), substitute in for Y and Y^* (equation 2) and divide through by $(k+w)(L)(MC_i^{1-\sigma})(n_i)$ and substitute in θ_i, ρ_i, and ω:

$$1 = \frac{\tau_i^{1-\sigma_i}(\tau_i^{1-\sigma_i} + \theta_i\rho_i^{1-\sigma_i}) + \omega\lambda(1 + \theta_i\rho_i^{1-\sigma_i}\tau_i^{1-\sigma_i})}{\rho_i^{\sigma_i}(\tau_i^{1-\sigma_i} + \theta_i\rho_i^{1-\sigma_i}) + \rho_i^{\sigma_i}\tau_i^{1-\sigma_i}\omega\lambda(1 + \theta_i\rho_i^{1-\sigma_i}\tau_i^{1-\sigma_i})} \qquad i=1,2. \qquad \textbf{(A2)}$$

Equation (A2) will form the basis of all the proofs. In all that follows, assume $L^*/L = \lambda < 1$. We impose $\theta_i = \lambda$[1] in equation (A2) and find the relative wage in each industry i that will maintain this equality. If the relative wage is identical in both industries then $\theta_i = \lambda$ is an equilibrium allocation of firms. However, if the relative wages necessary to maintain $\theta_i = \lambda$ are different in both industries, $w_1^*/w_1 \neq w_2^*/w_2$, then this is not an equilibrium distribution of firms. Since labour is mobile between industries within a country, the wages must be the same across

[1] Since we fix the relative number of firms in all the proofs, we can disregard the factor market clearing conditions (equation 17).

industries within a country.

Proposition 1

(a) **If $\tau=\infty$, then $w^*/w=1$, $n_i^*/n_i=\lambda$; and**

(b) **if $\tau=1$, then $w^*/w=1$, and n_i^*/n_i are indeterminate.**

Proof: (a) Show that if $\tau=\infty$, then $w^*/w=1$.

If $\tau=\infty$, equation (A2) reduces to $\omega=\rho$, written explicitly:

$$\frac{k+w^*}{k+w}=\frac{\delta_i/\gamma_i+w^*}{\delta_i/\gamma_i+w} \Rightarrow \frac{w_*}{w}[k-\frac{\delta_i}{\gamma_i}]=[k-\frac{\delta_i}{\gamma_i}] \qquad i=1,2. \tag{A3}$$

If $k \neq \delta_i/\gamma_i$, $w^*/w=1$.[2]

Show that if $w^*/w=1$, $\theta_i=\lambda$ is unique when $\tau=\infty$.

Setting $\tau=\infty$, $w^*/w=1$, equation (A2) collapses to $\theta_i=\lambda$.

(b) Show that if $\tau=1$, then $w^*/w=1$.

If $\tau=1$, equation (A2) reduces to:

$$1=\frac{[1+\theta_i\rho_i^{1-\sigma_i}]+[\omega\lambda(1+\theta_i\rho_i^{1-\sigma_i})]}{\rho_i^{\sigma_i}([1+\theta_i\rho_i^{1-\sigma_i}]+[\omega\lambda(1+\theta_i\rho_i^{1-\sigma_i})])} \qquad i=1,2. \tag{A4}$$

Hence, $\rho=1$ which implies $w^*/w=1$.

---

[2] In a fixed proportions model, if the industries differ with respect to factor intensities then $k=K/L \neq \delta_i/\gamma_i \neq \delta_j/\gamma_i$. If the industries have identical factor intensities then $K/L=\delta_i/\gamma_i$ and $w^*/w=1$ is trivial. That is, with identical factor intensities the model collapses to a one factor model which is internationally immobile. Hence, in autarky we need a numeraire for each country.

Show that if $w^*/w=1$, $\theta_i=\lambda$ is not unique when $\tau=1$.

Setting $\tau=1$, $w^*/w=1$, equation (A2) collapses to $\theta_i=\theta_i$. □

For propositions 2 to 4, first we need to show that $w^*/w<1$ for $1<\tau<\infty$. We proceed in two steps.

(i) Show that $w^*/w\neq 1$ for $1<\tau<\infty$.

Impose $w^*/w=1$, and show that equation (A2) cannot hold for $1<\tau<\infty$. Equation (A2) becomes:

$$1=\frac{\tau_i^{1-\sigma_i}(\tau_i^{1-\sigma_i}+\theta_i)+\lambda(1+\theta_i\tau_i^{1-\sigma_i})}{(\tau_i^{1-\sigma_i}+\theta_i)+\tau_i^{1-\sigma_i}\lambda(1+\theta_i\tau_i^{1-\sigma_i})} \quad \Rightarrow \quad \theta_i=\frac{\lambda-\tau_i^{1-\sigma_i}}{1-\lambda\tau^{1-\sigma_i}} \quad i=1,2. \tag{A5}$$

This implies that $\theta_1<\lambda$ and $\theta_2<\lambda$, which is not possible if factor market equilibrium is to hold. Therefore, $w^*/w\neq 1$ for $1<\tau<\infty$

(ii) Show that $d(w^*/w)/d\tau > 0$, evaluated at $w^*/w=1$ and $\tau=1$.

By totally differentiating equation (A2), we have:

$$\left.\frac{d(w^*/w)}{d\tau}\right|_{w=w^*,\tau=1}=\frac{2(1-\sigma_i)(1-\lambda^2)}{\sigma_i\left(\frac{\gamma_i/\delta_i}{1+(\gamma_i/\delta_i)w}\right)(1+\lambda^2+2\lambda)w}<0 \tag{A6}$$

So far, we have shown that for $\theta_i=\lambda$ to hold, at $\tau=\infty$ and $\tau=1$, $w^*/w=1$, hence we have our two endpoints. We have also shown that for $1<\tau<\infty$, $w^*/w\neq 1$. But since $d(w^*/w)/d\tau|_{w=w^*,\tau=1}<0$, and by appealing to continuity, $w^*/w<1$ for all intermediate values of τ. □

Proposition 2

Given that $w^*/w < 1$ for $1 < \tau < \infty$, if $\sigma_1=\sigma_2=\sigma$, $\tau_1=\tau_2=\tau$, $\gamma_1/\delta_1 > \gamma_2/\delta_2$, then $n_1^*/n_2^* > n_1/n_2$.

Proof: (i) Show that the relative wages required to maintain $\theta_i=\lambda$ is higher in industry 1 than industry 2 for intermediate values of τ.

We rewrite equation (A2) for industries 1 and 2 to reflect that the industries are identical in all respects except industry 1 is more labour intensive than industry 2, $\gamma_1/\delta_1 > \gamma_2/\delta_2$. The different relative factor intensities only enter in the ratio of marginal costs, ρ_i.

$$1=\frac{\tau^{1-\sigma}(\tau^{1-\sigma}+\lambda\rho_1^{1-\sigma})+\omega\lambda(1+\lambda\rho_1^{1-\sigma}\tau^{1-\sigma})}{\rho_1^{\sigma}(\tau^{1-\sigma}+\lambda\rho_1^{1-\sigma})+\rho_1^{\sigma}\tau^{1-\sigma}\omega\lambda(1+\lambda\rho_1^{1-\sigma}\tau^{1-\sigma})} \tag{A7}$$

$$1=\frac{\tau^{1-\sigma}(\tau^{1-\sigma}+\lambda\rho_2^{1-\sigma})+\omega\lambda(1+\lambda\rho_2^{1-\sigma}\tau^{1-\sigma})}{\rho_2^{\sigma}(\tau^{1-\sigma}+\lambda\rho_2^{1-\sigma})+\rho_2^{\sigma}\tau^{1-\sigma}\omega\lambda(1+\lambda\rho_2^{1-\sigma}\tau^{1-\sigma})} \tag{A8}$$

For $\theta_i=\lambda$ to be an equilibrium allocation of firms, both equations (A8) and (A9) must hold simultaneously for the same w, w^*.

By taking the second derivative of equation (A6) with respect to γ_i/δ_i, we have:

$$\left.\frac{d^2(w^*/w)}{d\tau\, d(\gamma/\delta)}\right|_{w^*=w,\tau=1} = -\frac{2(1-\sigma)(1-\lambda^2)}{\dfrac{\sigma^2(\gamma/\delta)^2 w}{1+\gamma/\delta}(1+2\lambda+\lambda^2)} > 0 \tag{A9}$$

Hence, w^*/w is higher for lower values of γ/δ, at τ close to 1. (The higher is γ/δ, the lower is the gradient).

(ii) Show that the relative wage required to maintain equation (A8) is different from the one required for equation (A8).

Notice that all the terms in equation (A8) are the same as those in equation (A9) except the ρ's. We set the ρ's equal and see if we can find a wage ratio, w^*/w, that is the same for both industries that will satisfy this.

Rewriting the ρ's in terms of relative wages, setting $\rho_2 = \rho_1$, $w_1^*/w_1 = w_2^*/w_2 = w^*/w$ and rearranging:

$$\frac{w^*}{w}\left[\frac{\delta_2}{\gamma_2 w}-\frac{\delta_1}{\gamma_1 w}\right]=\left[\frac{\delta_2}{\gamma_2 w}-\frac{\delta_1}{\gamma_1 w}\right] \tag{A10}$$

Since $w^*/w < 1$ for all $1 < \tau < \infty$, equation (A10) cannot hold. Therefore, the relative wage required in industry 2 is lower than the one required in industry 1 to maintain $\theta_i=\lambda$, for all $1 < \tau < \infty$. The equilibrium wage ratio will lie somewhere in between. Hence the equilibrium allocation of firms will be such that $n_1^*/n_1 > \lambda$ and $n_2^*/n_2 < \lambda$, which implies that $n_1^*/n_2^* > n_1/n_2$. □

Corollory 1: For intermediate values of transport costs, the large country is a net importer of capital.

Proof : Show that the demand for capital in the large country is greater than its initial endowment and the demand for capital in the small country is less than its initial endowment.

$$n_1^* \alpha \sigma \delta_1 + n_2^* \alpha \sigma \delta_2 < K^* \qquad n_1 \alpha \sigma \delta_1 + n_2 \alpha \sigma \delta_2 > K \tag{A11}$$

Taking the ratio of foreign to home demands for capital, substituting for $K^*/K=\lambda$, and rearranging:

$$\frac{\delta_1}{\delta_2} < \frac{(\lambda n_2 - n_2^*)}{(n_1^* - \lambda n_1)} \tag{A12}$$

Taking the ratio of the labour market clearing in the foreign to the home country and rearranging we see that the right hand side of equation (A12) is equal to γ_1/γ_2. □

Proposition 3:
Given $w^*/w < 1$ for $1 < \tau_i < \infty$, if $\gamma_1/\delta_1 = \gamma_2/\delta_2$, $\sigma_1 = \sigma_2 = \sigma$ and $\tau_1 > \tau_2$, then $n_1^*/n_2^* < n_1/n_2$.

Proof: Show that the wage relativity required to maintain $\theta_i = \lambda$ in industry 2 is higher than in industry 1, for all intermediate values of τ.
Totally differentiate equation (A2):

$$\frac{d(w^*/w)}{d\lambda} = \frac{(\rho w + w^*)([\rho^{-\sigma}-1]+2\lambda\rho^{1-\sigma}[1-\tau^{1-\sigma}])}{\frac{w^2}{\delta/\gamma+w}[(\sigma-1)\lambda\rho^{-\sigma}+(\sigma-2)\lambda^2\rho^{1-\sigma}+\sigma\rho^{\sigma-1}+(\sigma+1)\lambda\rho^{\sigma}+2\lambda^2\rho\tau^{1-\sigma}]} > 0$$

(A13)

Take the second derivative of equation (A13) with respect to τ. Label the numerator of equation (A13) $f(\tau)$ and the denominator $g(\tau)$. Note that both are positive. The derivatives of $f(\tau)$ and $g(\tau)$ are as follows:

$$f'(\tau)=-2\lambda\rho^{1-\sigma}(\rho w+w^{*})(1-\sigma)\tau^{-\sigma}>0 \qquad g'(\tau)=\frac{w^{2}}{\frac{\delta}{\gamma}+w}2\lambda^{2}\rho(1-\sigma)\tau^{-\sigma}<0 \qquad \text{(A14)}$$

Therefore:

$$\frac{d^{2}(w^{*}/w)}{d\lambda d\tau}=\frac{f'(\tau)g(\tau)-f(\tau)g'(\tau)}{g^{2}(\tau)}>0 \qquad \text{(A15)}$$

Hence, the higher the τ, the higher the gradient which means that industry 2 requires a higher wage relativity than industry 1 to maintain $\theta_i=\lambda$. The equilibrium wage ratio will lie somewhere in between. Hence, the equilibrium allocation of firms will be such that $n_1^{*}/n_1<\lambda$ and $n_2^{*}/n_2>\lambda$ which implies that $n_1^{*}/n_2^{*}<n_1/n_2$.

Proposition 4: Given that $w^{*}/w<1$ for $1<\tau<\infty$, if $\tau_1=\tau_2=\tau$, $\gamma_1/\delta_1=\gamma_2/\delta_2$, $\sigma_1>\sigma_2$, for $\tau\to\infty$ and $\tau\to 1$, then $n_1^{*}/n_2^{*}<n_1/n_2$.

Proof: Show that the wage relativity required to maintain $\theta_i=\lambda$ in industry 2 is higher than in industry 1, for τ close to ∞ and 1.

Take the second derivative of equation (A6) with respect to σ.

$$\left.\frac{d^{2}(w^{*}/w)}{d\tau d\sigma}\right|_{w^{*}=w,\tau=1}=-\frac{2(1-\lambda^{2})}{\frac{1}{\frac{\delta}{\gamma}+w}(1+\lambda^{2}+2\lambda)w}<0 \qquad \text{(A16)}$$

Hence, the higher is σ, the higher is the gradient, at τ close to 1. Therefore, a higher relative wage, w^{*}/w, is required in industry 2 than industry 1 to maintain

$\theta_i = \lambda$ as an equilibrium. Similarly for τ close to ∞.

$$\left.\frac{d(w^*/w)}{d\tau}\right|_{w=w^*,\tau\to\infty} = \frac{2(1-\sigma)(\lambda^2-1)}{\frac{\tau w}{\delta/\gamma+w}[2\sigma\lambda-2\lambda^2+\sigma\lambda^2+\sigma]} > 0 \tag{A17}$$

$$\left.\frac{d^2(w^*/w)}{d\tau d\sigma}\right|_{w^*=w,\tau\to\infty} = -\frac{2(\lambda^2-1)(2\lambda-\lambda^2+1)}{\frac{\tau w}{\delta/\gamma+w}[2\sigma\lambda-2\lambda^2+\sigma\lambda^2+\sigma]^2} > 0 \tag{A18}$$

The equilibrium wage ratio will lie somewhere in between. Hence, the equilibrium allocation of firms will be such that $n_1^*/n_1 < \lambda$ and $n_2^*/n_2 > \lambda$ which implies that $n_1^*/n_2^* < n_1/n_2$. □

APPENDIX 2

All the simulations have the following parameter values: $L=K=120$; $L^*=K^*=100$; $\alpha=2$; $\beta=1$.

Figures 1, 2 and 3:

$\sigma_1=\sigma_2=\sigma=3$; $\tau_1=\tau_2=\tau$; $\gamma_1=2/3$, $\delta_1=1/3$, $\gamma_2=1/3$, $\delta_2=2/3$.

Figure 4:

$\gamma_1=\gamma_2=.5$, $\delta_1=\delta_2=.5$; $\sigma_1=\sigma_2=\sigma=3$; $\tau_2=\tau_1+.1$.

Figure 5:

$\gamma_1=\gamma_2=.5$, $\delta_1=\delta_2=.5$; $\tau_1=\tau_2=\tau$; $\sigma_1=6$, $\sigma_2=4$;

Figure 6:

$\gamma_1=2/3$ $\gamma_2=1/3$, $\delta_1=1/3$, $\delta_2=2/3$; $\sigma_1=\sigma_2=\sigma=3$; $\tau_2=\tau_1+.1$;

CHAPTER 2

REGIONAL SPECIALISATION AND TECHNOLOGICAL LEAPFROGGING

There are numerous historical episodes where a technological leader loses its dominant position after some technological breakthrough. One example concerns the nineteenth century Norwegian shipping industry. The port of Risor was a major centre of sail based shipping industry. The development of steam technology rendered sail technologically obsolete, but did not lead to the abandonment of the technology in Risor. Steam based shipping activity became centred on Bergen and sail technology continued in Risor for several decades before being driven out of business. Following the eventual demise of sail, Risor never recovered its status as a centre of shipping activity. Other examples provide evidence of centres of activity that have been overtaken by new technologies, but then managed to switch to the new. In 1850, Britain was regarded as the world's only industrial economy. Yet by the first world war industrialisation had spread to other countries. Harley (1974) gives examples of British industries which were slow to adopt new techniques that were in use elsewhere. For instance Britain was slow to adopt capital using, labour saving techniques such as ring spindles in textiles and assembly line methods in the metal-working industries.

When a new technology becomes available, which is superior to and incompatible with an old technology, under what circumstances will the new technology be adopted? Will the new technology be adopted by the existing industrial leader or will it be adopted in a different location, another region or country? If the new technology is adopted in another location, will the new and old technologies co-exist or will the new technology drive out the old? Several papers have offered explanations of why there has been technological leapfrogging.[1] Brezis, Krugman and Tsiddon's (1993) explanation of technological leapfrogging among countries is based on non-pecuniary externalities. They assume that production is subject to external learning effects which are specific to each country and that when there is a major technological breakthrough, it yields a higher productivity than the old technology given the same amount of experience. So for the leading country which has extensive experience with the old technology and hence a higher wage, the new technology is initially inferior to the old. In contrast, the lagging country which has little experience with the old technology and hence a lower wage, can use its wage advantage to adopt the new technology. Over time, the lagging country gains more experience with the new technology and takes over as the leading country.

The mechanism in this Chapter is quite different being based on pecuniary externalities arising from transactions in the presence of imperfect competition. I present a model with two regions, with labour immobile between the two regions, and two industries which are vertically linked. The upstream industry is a Cournot oligopoly producing homogenous components which are supplied to the downstream industry. The downstream industry is perfectly competitive producing homogenous final products which are supplied to the rest of the world. The vertical linkages between the two industries create forces for the agglomeration of the two industries in the one location as in Krugman and

[1] The industrial organization literature offers an explanation of why there is leapfrogging among firms based on what is known as the 'replacement effect'. (See Tirole (1988)). The argument is that an existing monopolist has less incentive to innovate than a rival since it would be replacing itself. Gilbert and Newberry (1982) showed that a monopolist is still likely to innovate ahead of rivals in a world of perfect certainty; and Reinganum (1983) showed that in a world of uncertainty a monopolist is unlikely to innovate ahead of potential rivals.

Venables (1995), Venables (1996a) and Venables (1996b). There are demand linkages as an increase in the scale of operation of the downstream industry benefits upstream firms. This has a feedback effect as the price of upstream goods is decreasing in the number of upstream firms, due to increased competition among upstream firms - cost linkages which benefit downstream firms. The interaction of these forces creates pecuniary externalities, encouraging regional specialisation.

Why couldn't one upstream firm enter the other region with a low price and take advantage of the lower wage there? If a single upstream firm could commit not to act like a monopolist, it would attract downstream firms to enter which would in turn attract more upstream firms to enter, creating demand and cost linkages. It would be possible for an upstream firm to commit to a low price if the staging of the game were such that upstream firms made their quantity decisions before downstream firms made their entry decisions in which case regional specialisation would never be an equilibrium. However, it seems more realistic to suppose that entry decisions are taken before quantity decisions. With this staging of the game, a potential upstream entrant cannot commit not to act like a monopolist. Consequently, downstream firms will not enter unless the monopoly price is low enough to cover their fixed costs. The game theoretic interactions between the firms are crucial for regional specialisation in this model.[2]

When a new technology becomes available it does not benefit from the agglomeration of firms using the old technology since it is assumed that the two technologies are incompatible, like steam and sails. The new technology, which

[2] Krugman and Venables (1995) and Venables (1996a) abstract from game theoretic interactions by employing the Dixit-Stiglitz framework. However, in Venables' (1996b) Cournot oligopoly model the results about the effects of trade policy on industrial development are sensitive to the nature of the game.

I assume to be labour augmenting, is therefore most likely to be adopted in the 'lagging' region where the wages are lower. I show that there is an equilibrium where the two technologies co-exist, as did steam and sails in Norway. So according to this model, Risor's failure to introduce the new technology was because the existing agglomeration raised the prices of immobile factors (labour and also port space) in Risor relative to Bergen and its failure to switch was due to the benefits associated with the agglomeration of sail technology related activities.

The model is developed in Section 1 of this Chapter; Section 2 derives the conditions for regional specialisation; Section 3 analyses the circumstances under which the new technology will be adopted and where it will be adopted; Section 4 concludes and briefly mentions some policy implications. Appendix 1 of this Chapter sets out some of the derivations of the model and Appendix 2 contains the parameter values of the simulations.

1. THE MODEL

I develop a model of two vertically linked industries where firms can locate in either of two regions. Firms must choose their location and their technology. Initially, only one technology is available but then there is an unanticipated technological breakthrough - a new superior technology, incompatible with the old, becomes available. Upstream firms require labour to produce components which they sell to downstream firms in their own region. And downstream firms use components and labour to produce a final, homogenous product which they sell to the rest of the world. Labour is immobile between the two regions. So the two regions are linked by their competition for final product demand from the rest of the world.

1.1 Assumptions of the Model

Assumption 1: Firms play a four stage game as follows: In stage 1, **upstream firms** choose whether to enter and in which region. To enter each upstream firm must pay a fixed cost, F, and choose its technology, θ^k. There are two technologies available, indexed k=A,B. I set out the general model where both technologies are available. When solving for equilibria, I assume that initially only one technology is available, θ^A. At some future date there is an exogenous shock where a new superior technology, incompatible with the old, becomes available, θ^B. In stage 2, **downstream firms** choose whether to enter and in which region. To enter each downstream firm must pay a fixed cost, f, and choose its technology, θ^k. In stage 3 upstream firms choose quantities, competing a la Cournot. In the final stage downstream firms are assumed to be price takers.

I assume that firms make their entry decisions before choosing quantities since setting up a firm takes more time than adjusting quantities. The fixed costs commit firms to a particular technology.

The game is solved through backward induction so that equilibrium is subgame-perfect.

Assumption 2: Demand for final products only comes from consumers in the rest of the world:

$$Y^d = p^{-\eta} \tag{1}$$

where Y^d is the demand for final products, p is the price of final products and η is the elasticity of demand. This functional form is chosen for simplicity.

Assumption 3: The cost function for each downstream firm in region i is:

$$c_i=(w_i\theta^k)^{1-\mu}q_i^{\mu}[f+ay_i+by_i^2] \quad i=1,2 \quad a>0 \quad b>0 \tag{2}$$

where w_i is the wage in region i, q_i is the price of upstream components in region i, μ is the share of costs of components in the total cost of production, and y_i is output per downstream firm in region i.

A Cobb-Douglas technology is chosen for simplicity. The cost function gives U shaped average cost curves and upward sloping marginal cost curves ensuring that there is a unique level of equilibrium output for each firm.

Assumption 4: The cost function for each upstream firm in region i is:

$$C_i=(F+\beta x_i)\theta^k w_i \tag{3}$$

where x_i is the output per upstream firm in region i and $\beta\theta w_i$ is marginal cost.

Assumption 5: Trade costs on components produced by upstream firms are so high that no trade in components takes place between the two regions.

Assumption 6: Labour is immobile between the two regions and each region has a perfectly competitive labour market with the labour supply function, L_i^s, defined by:

$$\begin{aligned} L_i^s&=0 \quad if\ w_i<w_0 \\ L_i^s&=w^{\lambda} \quad if\ w_i\geq w_0 \end{aligned} \tag{4}$$

If w_i is greater than or equal to the reservation wage, w_0, the elasticity of labour supply is λ. At a wage below w_0, no labour is supplied to these industries - it is all employed in some other industry which is not explicitly modelled here. Again, this functional form is chosen for simplicity.

Assumption 7: The new technology is labour augmenting, thereby affecting the cost functions of upstream and downstream firms, and it is incompatible with the old technology. The way technology enters the model does not affect the results. For instance, the new technology could be modelled as a fall in upstream firms' marginal cost and the results would still be the same. However, the incompatibility of the two technologies is important for the results.

1.2 Solving the model

STAGES 3 AND 4

I solve for prices and quantities for a given number of upstream firms, n_i, and a given number of downstream firms, m_i, in each region i in three steps. First, I solve for prices and quantities in the downstream market. Second, I solve for prices and quantities in the upstream market. Finally, I determine the factor market clearing condition.

First, consider the behaviour of downstream firms. Each firm chooses how much to produce by taking the final price of goods as given. Setting price equal to marginal cost, the inverse supply function for each firm is:

$$p=(w_i\theta^k)^{1-\mu}q_i^{\mu}(a+2by_i) \qquad (5)$$

Demand for inputs is derived using Shephard's lemma, where demand for components, X_i^d, in region i is:

$$X_i^d=\mu(w_i\theta^k)^{1-\mu}q_i^{\mu-1}[f+ay_i+by_i^2]m_i \tag{6}$$

and demand for labour by downstream firms, L_i^d, in region i is:

$$L_i^d=(1-\mu)w_i^{-\mu}(\theta^k)^{1-\mu}q_i^{\mu}[f+ay_i+by_i^2]m_i \tag{7}$$

The equilibrium price of final goods is determined by aggregating equation (5) across all firms in both regions and equating this aggregate supply function to the demand function given by equation (1). The equilibrium output for each firm is then determined by substituting the equilibrium price into equation (5).

Second, consider the behaviour of upstream firms. Each firm chooses quantity by setting marginal revenue equal to marginal cost, taking as given the quantity of all other upstream firms, the number of upstream firms and the number of downstream firms. The first order condition for each upstream firm in region i is:

$$q_i(1-\frac{1}{n_i\epsilon_i})=\theta^k\beta w_i \tag{8}$$

where ϵ_i is the absolute value of the elasticity of derived demand for components. It is calculated by differentiating equations (1), (5) with $Y^d=y_im_i+y_jm_j$, and (6), with respect to y_i, p, q_i and X_i^d. The derivations are in Appendix 1.

$$\epsilon_i=(1-\mu+\frac{\mu\eta(a+2by_i)^2(m_iy_i+m_jy_j)}{(f+ay_i+by_i^2)[(a+(1+\eta)2by_i)m_i+\eta 2bm_jy_j]}) \tag{9}$$

The elasticity of derived demand can be decomposed into two effects: a substitution effect and an output effect. An increase in the price of components relative to the price of labour will lead firms to substitute labour for components. This effect is captured by the first term in equation (9), which is one minus the share of components in total costs, denoted by μ, multiplied by the elasticity of substitution which is equal to one for a Cobb-Douglas technology. The substitution effect is larger the smaller is the share of components in total costs; and the larger the elasticity of substitution between factors.

A change in the price of factors will also lead to an output effect. An increase in the price of components increases the cost of production and hence reduces the amount of output firms are willing to supply, which affects the price and demand for final products. The output effect is larger the larger is the share of components in total costs; and the larger is the elasticity of demand for final products, η. The output effect is smaller in this model than in the 'usual' case because the entry decisions of downstream firms have already taken place, the number of downstream firms is determined in stage 2 of the game.

Equilibrium in the upstream industry is given by equating demand for components (equation (6)) to the supply of components:

$$n_i x_i = \mu (w_i \theta^k)^{1-\mu} q_i^{\mu-1} [f + a y_i + b y_i^2] m_i \tag{10}$$

Demand for labour by upstream firms, L_i^u, is derived by Shepard's lemma:

$$L_i^u = (F + \beta x_i) \theta^k n_i \tag{11}$$

Finally, labour market equilibrium is determined by equating the labour supply in each region to the sum of labour demand from upstream and downstream firms in each region:

$$w_i^{\lambda}=(1-\mu)w_i^{-\mu}(\theta^k)^{1-\mu}q_i^{\mu}[f+ay_i+by_i^2]m_i+(F+\beta x_i)\theta^k n_i \quad \text{if } w_i \geq w_0 \tag{12}$$

That completes stages 3 and 4 of the game. Equations (5), (8), (9), (10) and (12) solve for y_i, q_i, ϵ_i, x_i, and w_i for given m_i and n_i.

STAGE 2

Downstream firms decide whether to enter, and if so in which region and with which technology. There is free entry and exit into the industry so profits are driven to zero. Since each firm is so small relative to the whole industry we can ignore the integer problem. Therefore:

$$\pi_i=py_i-[(w_i\theta^k)^{1-\mu}q_i^{\mu}][f+ay_i+by_i^2]=0 \tag{13}$$

Substituting in for price equals marginal cost from equation (5) into equation (13), we see that the equilibrium level of output is unique and independent of prices and the number of firms. This is a direct consequence of the cost function.

$$y_i=\sqrt{\frac{f}{b}}=y \tag{14}$$

Substituting for y in equation (9), the absolute value of the elasticity of derived demand for components is:

$$\epsilon_i=(1-\mu+\frac{\mu\eta(a+2by)^2(m_i+m_j)y}{[(a+(1+\eta)2by)m_i+\eta 2bm_jy][f+ay+by^2]} \tag{15}$$

Normalising so that a=b=f, the equilibrium level of y is equal to one. Then:

$$\epsilon_i=(1-\mu+\frac{3\mu\eta(m_i+m_j)}{m_i(3+2\eta)+2\eta m_j}) \tag{16}$$

The absolute value of the elasticity of derived demand for components, ϵ_1, is greater than one if the absolute value of the elasticity of demand for final goods, η, is greater than $3m_1/(m_1+m_2)$, provided that μ is positive. If $m_2=0$, then $-\eta$ must be greater than 3 for $\epsilon_1>1$. Therefore $-\eta > 3$ is sufficient for $\epsilon_i>1$. If the absolute value of ϵ_i is less than or equal to one then if there were only one upstream firm it would want to set an infinite price, therefore downstream firms would not enter.

The number of downstream firms are determined by substituting in for a=b=f, and y=1 into equations (1), (5), and (12); and also substituting in for x_i into equation (12) from equation (10).

$$p^{-\eta}=(m_1+m_2) \tag{17}$$

$$MC_i=AC_i=(w_i\theta^k)^{1-\mu}q_i^{\mu}3f \tag{18}$$

$$w_i^{\lambda}=(1-\mu)w_i^{-\mu}(\theta^k)^{1-\mu}q_i^{\mu}3fm_i+\mu\beta(\theta^k)^{2-\mu}w_i^{1-\mu}q_i^{\mu-1}3fm_i+F\theta^k n_i \tag{19}$$

So equations (8), (16), (17), (18) and (19) solve for p, m_i, q_i, ϵ_i and w_i. We can see from equation (8) that if $\epsilon_i=1$, the price of upstream components, q_i, is equal to infinity if there is only one upstream firm and from equation (18) we see that average costs would also be infinity and hence no downstream firm would enter.

STAGE 1

Upstream firms choose whether to enter or not, and if they enter they choose the region and the technology. There is free entry and exit so in equilibrium profits are non-negative.

$$\Pi_i = q_i x_i - (F + \beta x_i)\theta^k w_i \geq 0 \tag{20}$$

2. REGIONAL SPECIALISATION

Initially, suppose that there is only one technology available denoted by θ^A. I show that there is an equilibrium where firms only locate in one region. Since the regions are symmetrical, regional specialisation can take place in either region. For concreteness, suppose that it is region 1 and denote this equilibrium configuration by (A,0) which indicates that firms in region 1 are operating with technology A and there are no firms in region 2.

To show that (A,0) is an equilibrium, first we solve the model for one region in the same way as in Section 1 above, and then check that it is in fact an equilibrium. I drop the subscript i since only one region is operating.

Equilibrium price, quantity and number of firms in the downstream market are determined using equations (1), (5) and (13). Substituting for price equals marginal cost into equation (13) and normalising so that a=b=f, we saw that y=1. Substituting for y and setting demand equals supply, Y^d=m, we can determine the price of final goods, p, and the number of downstream firms, m:

$$p=(w\theta^{A})^{1-\mu}q^{\mu}3f \tag{21}$$

$$m=[(w\theta^{A})^{1-\mu}q^{\mu}3f]^{-\eta} \tag{22}$$

Equilibrium price and quantity for upstream firms are determined from equations (8), (16) and (10). The elasticity of derived demand is from equation (16) with $m_2=0$. The quantity produced by each upstream firms is determined by using equation (21) in equation (10):

$$q=\theta^{A}\beta w\left(\frac{n\epsilon}{n\epsilon-1}\right) \quad where \ \epsilon=1-\mu+\frac{3\mu\eta}{3+2\eta} \tag{23}$$

$$x=\mu(w\theta^{A})^{1-\mu}q^{\mu-1}3fmn^{-1}=\frac{\mu pm}{qn} \tag{24}$$

The zero profit condition determines the equilibrium number of upstream firms[3].

$$\Pi=qx-(F+\beta x)\theta^{A}w=0 \tag{25}$$

The equilibrium wage is given by equating labour supply to labour demand from upstream and downstream firms. Using equations (21), (24), (25) and y=1 in the labour market clearing condition (equation (12)), the equilibrium wage is:

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[3] I solve the model for a continuous number of firms for simplicity - I then use integers in the numerical simulations.

$$w=(pm)^{\frac{1}{1+\lambda}} \quad if\ w \geq w_0 \tag{26}$$

Substituting in for q, x and w from equations (23), (24) and (26) into the upstream zero profit condition (equation (25), the equilibrium number of firms is given by:

$$n=\sqrt{\frac{\mu(pm)^{\frac{\lambda}{\lambda+1}}}{\epsilon\theta^{A}F}} \tag{27}$$

From equations (23) and (27) we can identify the pecuniary externalities which arise from the presence of vertical linkages between the two industries and get some intuition for the agglomeration forces present. From equation (27) we see that the number of upstream firms and the value of downstream output, pm, are positively related. The higher is the value of downstream output, the higher the profits of upstream firms which induces entry thereby increasing the number of upstream firms, which is referred to as the demand linkage. This has a feedback effect as the price of upstream goods, q, is decreasing in n (see equation (23)), which is the cost linkage. The price of upstream components falls due to the increased intensity of competition among upstream firms. A lower q reduces average costs of downstream firms increasing the equilibrium number of downstream firms and results in a higher value of output. Multiplying equations (21) and (22) and substituting in for wages, from equation (26), we see that the value of output in the downstream industry is decreasing in q:

$$(pm)^{\delta}=[\theta^{1-\mu}q^{\mu}3f]^{-(\eta-1)(\lambda+1)} \qquad \delta=(\lambda+1)+(\eta-1)(1-\mu)>0 \tag{28}$$

The configuration (A,0) is an equilibrium if the agglomeration benefits of all firms locating in the one region outweigh the wage cost advantage of region 2. Two conditions must be satisfied: first, the equilibrium wage, w_1, must be greater than the reservation wage, w_0, otherwise no labour will be supplied. I set w_0 so that this condition is met; second, no single upstream firm from region 1 can enter region 2 and earn higher profits given the number of upstream firms is equal to n_1^*-1, where n_1^* is the number of upstream firms determined by the zero profit condition, equation (27),

$$\Pi_1(n_1=n_1^*, n_2=0) > \Pi_2(n_1=n_1^*-1, n_2=1)$$

and a new potential entrant cannot enter region 2 and make positive profits,

$$\Pi_2(n_1=n_1^*, n_2=1) < 0.$$

To calculate whether it is profitable to enter region 2, a potential 'deviating' upstream firm takes the number of upstream firms in region 1 as given since the number of upstream firms is determined in stage 1 of the game. If it is an existing firm from region 1, then it takes the number of upstream firms in region 1 equal to n_1^*-1, and if it is a new entrant then it takes the number of firms in region 1 equal to n_1^*. The potential deviant calculates its profits from entering region 2 by calculating the number of downstream firms (stage 2 of the game) and the new prices and quantities (stages 3 and 4 of the game) that would prevail if it were the only upstream firm to enter region 2 and for the given number of upstream firms in region 1. A firm from region 1 will enter region 2 if it can earn higher profits in region 2; and a potential new entrant will enter region 2 if it can earn non-negative profits. A profitable opportunity for an upstream firm to enter region 2 is possible only if downstream firms can cover their fixed costs in region 2 given there is only one upstream firm in region 2.

To illustrate the candidate equilibrium (A,0) I reduce the model to two equations, which are plotted in Figure 1[4]. First, the labour market clearing condition, equation (12) substituting in for q_1, y_1, x_1 and m_1 from equations (8), (10), (14) and (22), which gives the labour market clearing wage for any given number of upstream firms in region 1 and $n_2=0$. The labour market clearing wage is increasing in the number of upstream firms. The higher the number of upstream firms, the higher the number of downstream firms, together increasing the demand for labour and bidding up the wage. Second, the zero profit condition, equation (25) substituting in for q_1, y_1, x_1 and m_1, which gives the maximum wage that upstream firms can afford to pay for any given number of upstream firms in region 1 and $n_2=0$. The zero profit function wage is decreasing in the number of upstream firms. The higher the number of firms, the more competition and the lower the price of upstream components and hence the lower the wage that upstream firms can afford to pay. At the intersection of the two functions, the wage which satisfies labour market clearing also satisfies the zero profit condition for upstream firms. However, taking into account the integer constraint on the number of upstream firms, the candidate equilibrium (A,0) is just to the left of this intersection at point E where labour demand equals labour supply at $n_1^*=6$. At point E, upstream firms are making positive profits since the zero profit function lies above the labour market clearing condition. But if one more firm were to enter all firms would make negative profits since the labour market clearing wage is above what upstream firms can afford to pay at $n_1=7$.

The configuration (A,0) at point E in Figure 1 is an equilibrium if the two conditions above are satisfied. One, the reservation wage, w_0, must be below the labour market clearing wage at point E. I set the reservation wage so that it is below point E. Two, there are no profitable opportunities for entry into region

[4] The two equations are derived in Appendix 1 and the parameter values of the simulations are given in Appendix 2.

2. The profits of a 'deviating' upstream firm are calculated from equation (20) with $n_1=n_1^*$ and $n_2=1$, using equations (8), (16), (17), (18) and (19) to solve for p, m_i, q_i, ϵ_i and w_i. Substituting for q_2 and x_2 into equation (20), $\Pi_2(n_1=n_1^*, n_2=1)<0$ if

$$\frac{\mu m_2}{(m_1+m_2)^{\frac{1}{\eta}}} < F\theta^A w_2 \epsilon_2 \tag{29}$$

For the parameter values underlying Figure 1, the profits of an upstream firm, for $n_1=n_1^*$ and $n_2=1$, are negative so condition 2 given in equation (29) is satisfied. This condition is also satisfied for n_1^*-1 and $n_2=1$. So for the parameter values underlying Figure 1, the configuration (A,0) is an equilibrium.

It should be noted that (A,0) is an equilibrium and not the only equilibrium. Since the two regions are symmetric (0,A) is also an equilibrium. Furthermore, (A,A) is an equilibrium with an equal number of firms in both regions but may be unstable.

Regional specialisation is an equilibrium only for certain parameter values. In particular, the elasticity of demand for final products must be 'low', the share of costs of components in the total cost of production for downstream firms, μ, must be 'high', and the elasticity of labour supply must be 'high' for regional specialisation to be possible. Figure 2 shows that an increase in the elasticity of demand, η, shifts the zero profit function to the right and the labour market clearing function to the left, resulting in a higher number of firms and a higher wage, from E to E_1. A higher η results in a higher elasticity of derived demand, ϵ, and hence a lower price of components for any given wage. This leads to an increase in demand for components and a corresponding increase in supply of final products, which will only lead to a small decline in the price of final goods when η is high. The increase in the supply of components and final goods leads to an increase in the demand for labour, hence an increase in the wage. Suppose that we are at point E_1 in Figure 2. Is this an equilibrium? Calculating the profits of a 'deviating' upstream firm, we find that there is a profitable deviation - the profits of an upstream firm in region 2, given $n_1=n_1^*$ and $n_2=1$, are positive. So condition 2 given in equation (29) is not satisfied for high values of η. For high values of η the zero profit condition of downstream firms in region 2 (equation 13) is satisfied for $n_1=n_1^*$ and $n_2=1$. Although a higher η means there is room for more firms in the market it also results in a higher wage which increases the size of the wage advantage in region 2. The higher is η, the less likely that (A,0) is an equilibrium. For the parameter values underlying Figure 2, regional specialisation is not an equilibrium. In this case the wage advantage of region 2 outweighs the agglomeration benefits of region 1. The unique equilibrium is (A,A), with an equal number of firms in each region.

Now, consider how a change in μ affects the candidate equilibrium (A,0), say a change from $\mu=0.6$ to $\mu'=0.4$. A lower μ results in a lower number of upstream firms and a lower wage in Figure 1 so that point E' would be to the left and below E in Figure 1. However at $\mu'=0.4$, (A,0) is not an equilibrium. Even though the wage is lower so that the wage advantage of region 2 is lower, the benefits of agglomeration are not as high now. So a 'deviating' upstream firm will find it profitable to enter region 2 even though the wage gap is not so high. Again, condition 2 given in equation (29) is not satisfied, and the unique equilibrium is (A,A), with an equal number of firms in both regions.

Figure 3 shows that an increase in the elasticity of supply of labour, λ, also increases the number of upstream firms in region 1 but leads to a fall in the wage, from E to E_1. Large increases in labour demand will only lead to small increases in wages if labour supply is very elastic. The higher is λ the more likely that the configuration (A,0) is an equilibrium - condition 2 in equation (29) is satisfied. The more elastic the labour supply, the lower the equilibrium wage in region 1, therefore the smaller is the wage advantage in region 2.

If the elasticity of derived demand were less than one then (A,0) would always be an equilibrium since a potential upstream entrant into region 2 would want to set an infinite price. Anticipating this behaviour, downstream firms would choose not to enter region 2. The elasticity of derived demand is less than one if $a=0$, which means that the marginal cost curve of downstream firms goes through the origin; and if the elasticity of demand for final goods is very low.

In contrast, if the staging of the game were such that upstream firms chose their quantities before downstream firms made their entry decisions, then a potential upstream entrant into region 2 would set a price equal to the one in region 1 and take advantage of the low wage in region 2, that is it would be able to commit to a low price. Consequently (A,0) would not be an equilibrium. However that staging of the game is unrealistic since quantity decisions can be altered more quickly than entry decisions.

3. NEW TECHNOLOGY

Suppose that the parameter values are such that regional specialisation is an equilibrium and that the equilibrium configuration (A,0) is given by history. Then there is a technological breakthrough where a new technology becomes available, $\theta^B < \theta^A = 1$, which is superior to and incompatible with the old technology. Will the new technology be adopted? If so, in which region? What are the equilibrium configurations?

For the new technology to be adopted, an existing upstream firm from region 1 must be able to make higher profits by entering either region 1 or region 2 with the new technology, given n_1^*-1 upstream firms in region 1, or a new upstream entrant must be able to make non-negative profits by entering either region with the new technology, given n_1^* upstream firms in region 1. When calculating the profits of the 'deviating' upstream firms, the number of other upstream firms is taken as given, as this is determined in stage 1 of the game, but the number of downstream firms, quantities and prices are re-calculated as these are determined in the subsequent stages of the game. I assume that the fixed cost is paid every period so that even if a firm continues to operate with the old technology it must pay the fixed cost again[5].

The new technology is labour augmenting. If an upstream firm were to enter region 1 with the new technology, it does not derive any of the agglomeration benefits enjoyed by the firms operating with the old technology since the two technologies are assumed to be incompatible. The pecuniary externalities are the same in either region but the wage in region 2 is lower than in region 1. If an upstream firm were to enter region 2 with the new technology, it has the benefit of the new technology as well as the advantage of a lower wage in that region. So a profitable opportunity to enter region 2 with the new technology will arise before that of entering region 1 with the new technology. The lower is θ^B relative to θ^A, the more likely that there will be a profitable opportunity for a single upstream firm to enter region 2.

Figure 4 is a plot of the maximum wage a single upstream firm can afford to pay in region 2 and the labour market clearing wage in region 2 for different values of θ^B, given there are n_1^* old technology firms operating in region 1. The number of upstream firms in region 1, n_1^*, was determined by the zero profit condition

[5] I discuss the implications of this assumption below.

in equation (27) and illustrated in Figure 1 at point E. If an upstream firm enters region 2 with the new technology it must pay the wage given by the labour market clearing condition, equation (19), with p, m_i, q_i, and ϵ_i for $i=1,2$ determined by equations (8), (16), (17) and (18) for $n_1=n_1^*$ and $n_2=1$. The lower is θ^B, the lower the average costs of downstream firms in region 2 which leads to more entry and a higher wage. So the labour market clearing function is increasing in w_2, $(1/\theta^B)$ space. The zero profit function is equation (20), calculated for $n_1=n_1^*$, $n_2=1$, with p, m_i, q_i, and ϵ_i for $i=1,2$ also determined by equations (8), (16), (17) and (18). An upstream firm can make positive profits by entering region 2 if the zero profit function lies above the labour market clearing function - the maximum wage it can afford to pay is higher than the actual wage it would have to pay. At θ^{B*}, which is given by the intersection of the two functions in Figure 4, a single upstream firm can enter region 2 with the new technology and make zero profits and downstream firms can cover their fixed costs, given $n_1=n_1^*$ and $n_2=1$.

At θ^{B*}, the configuration (A,0) is no longer an equilibrium. There is a new equilibrium (A,B), where region 1 operates with the old technology and region 2 operates with the new technology. A move from equilibrium (A,0) to (A,B) is what is referred to as technological leapfrogging - region 2 takes over as the industrial leader. It should be noted that there are multiple equilibria in this model. If (A,B) is an equilibrium so is (B,A).

Equilibrium (A,B) is determined by solving the two region model in section 1 for $\theta^k=\theta^A$ in region 1, and $\theta^k=\theta^B$ in region 2. Simulating the model for $\theta^A=1$ and for different values of $\theta^B<1$, we see in Figure 5 that the lower is θ^B, the higher the number of firms in region 2 and the lower the number of firms in region 1 and Figure 6 shows that the wage in region 2 increases as θ^B falls and the wage in region 1 falls with θ^B. For any given number of firms, a lower θ^B implies that each upstream firm can afford to pay a wage which is higher than the labour market clearing wage. Positive profits induce entry of upstream firms which leads to a lower price of components, which in turn leads to an increase in demand for labour by both upstream and downstream firms bidding up the wage. The increase in supply of final products in region 2 leads to a fall in the price of final goods which leads to a fall in demand for components in region 1 and the exit of upstream and downstream firms in region 1. The fall in demand for labour in region 1 leads to a fall in the wage in region 1.

Configuration (A,B) is an equilibrium if the following conditions are satisfied: first, the wages in region 1 and region 2 are above the reservation wage; second no existing upstream firm from region 1 or from region 2 can make higher profits by changing its behaviour. No upstream firm will want to enter region 2 with the old technology since it does not derive any benefits from the agglomeration of new technology firms and it would have to pay a higher wage in that region. We need to check that a single existing upstream firm located in region 1 or in region 2 cannot enter region 1 with the new technology and earn higher profits, Π_1',

$$\Pi_1'(n_1(\theta^A)=n_1^*-1, n_2(\theta^B)=n_2^*, n_1(\theta^B)=1) < \Pi_1(n_1(\theta^A)=n_1^*, n_2(\theta^B)=n_2^*)$$
$$\Pi_1'(n_1(\theta^A)=n_1^*, n_2(\theta^B)=n_2^*-1, n_1(\theta^B)=1) < \Pi_2(n_1(\theta^A)=n_1^*, n_2(\theta^B)=n_2^*)$$

Further, a potential entrant cannot enter region 1 with the new technology and earn positive profits given the number of upstream firms in region 1 operating with the old technology and the number of upstream firms in region 2 operating with the new technology. We also need to check that a positive number of old technology upstream firms in region 1 and a positive number of new technology upstream firms in region 2 are earning non-negative profits.

The configuration (A,B) will be an equilibrium for certain parameter values. If θ^B is very low, the price of final goods will fall so low due to the increasing number of new technology firms operating in region 2 that firms in region 1 will not be able to continue to make non-negative profits and will exit.

After the introduction of the new technology, the new equilibrium configuration may be (A,B) or (B,A) where the two technologies co-exist. For very low values of θ^B the equilibrium configuration may be (0,B) where the industry in region 1 is completely wiped out and there is an agglomeration of new technology firms operating in region 2 or (B,0) with all the new technology firms agglomerated in region 1. Alternatively, the equilibrium configuration may be (B,B) where there is an equal number of firms in both regions operating with the new technology.

If the fixed cost for upstream and downstream firms is paid every period, we cannot say which equilibrium will be the equilibrium. All we can say is that these equilibria exist. However, if the fixed cost is an entry cost which is only paid once then we could say which is the equilibrium. Suppose that (A,0) is given to us by history so that there is only one technology available and all the firms are operating in region 1. Then a new technology becomes available which makes entry in region 2 profitable. A firm in region 1 would only exit if it could not cover its average variable cost. Consequently, the equilibrium configuration would be (A,B) and not (B,A) when $\theta^B=\theta^{B*}$. As the new technology improves, technology A will be abandoned and the industry in region 1 will either disappear or adopt the new technology.

4. CONCLUSIONS

This Chapter suggests that at times of major technological breakthroughs a leading region may lose its dominant position to a lagging region if the new technology is incompatible with the old. The fact that it was a leading region implies higher wages which may prevent it from adopting the new superior technology. The leading region benefits from the agglomeration of firms arising from vertical linkages. When a new technology arrives, it does not benefit from the existing agglomeration since it is incompatible with the old technology. Consequently, it is more likely to be adopted in the lagging region which has lower wages. Furthermore, it is possible that the two technologies can co-exist. The new technology region has more firms operating and hence a higher wage. The old technology region has less firms operating so the agglomeration benefits are lower, but this is offset by a lower wage enabling it to continue to compete with the new technological leader.

These results raise policy questions for the A technology region. The government may want to consider a policy which would make it profitable for the new technology to be adopted as soon as it becomes available. Free entry into the industry means that profits of downstream firms are zero and at least close to zero for upstream firms. However, the wage is higher with the new technology so workers would certainly be better off. There are a number of different instruments that could achieve this objective. The government could target the co-ordination failure between the upstream firms or directly subsidise the new technology so that there is an immediate switch to the new technology. Alternatively, the government could provide tax credits or accelerated depreciation allowances on existing capital stock.

Figure 1

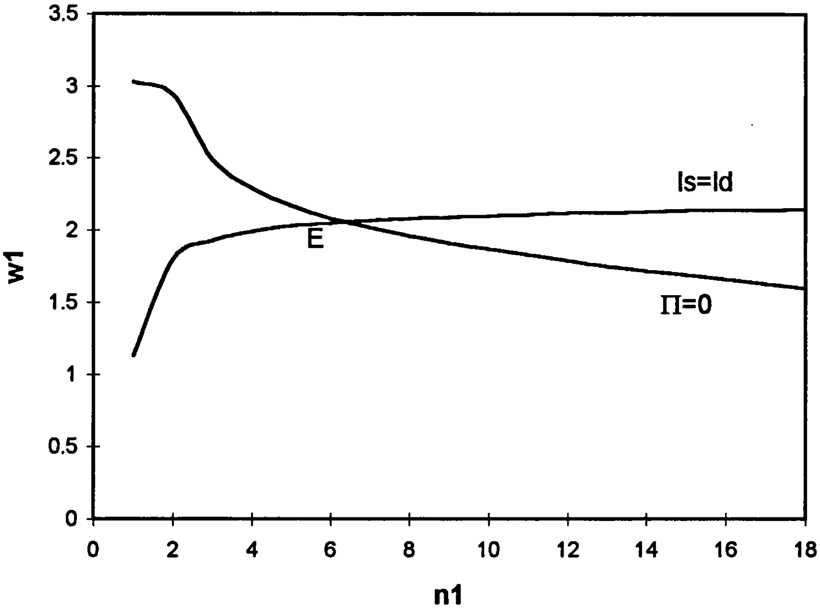


Figure 2

Increase in elasticity of demand

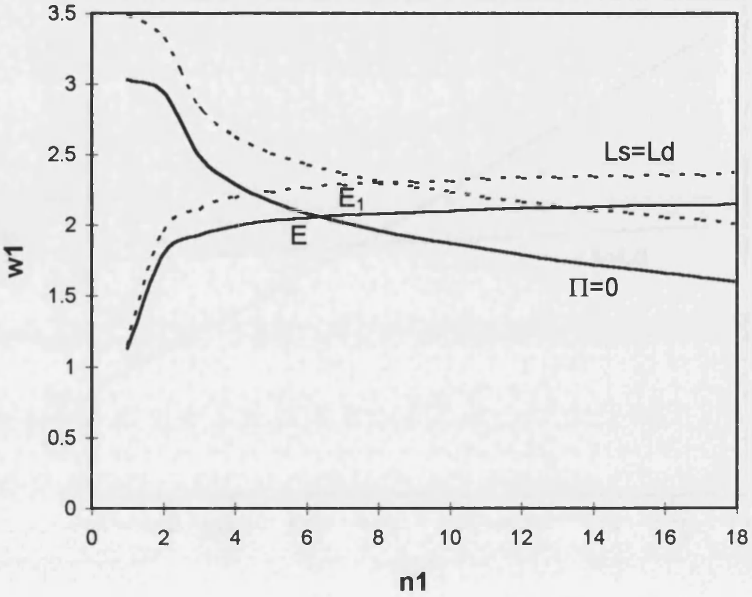


Figure 3

Increase in elasticity of labour supply

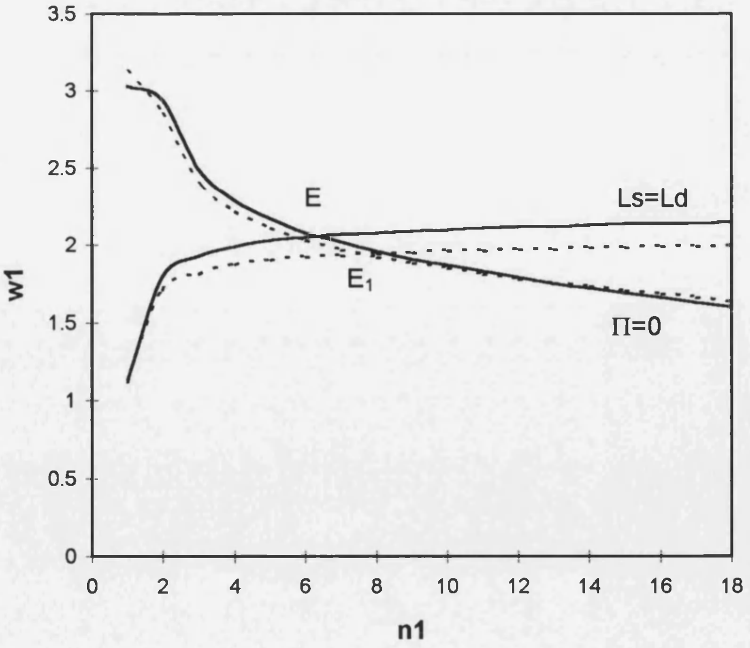
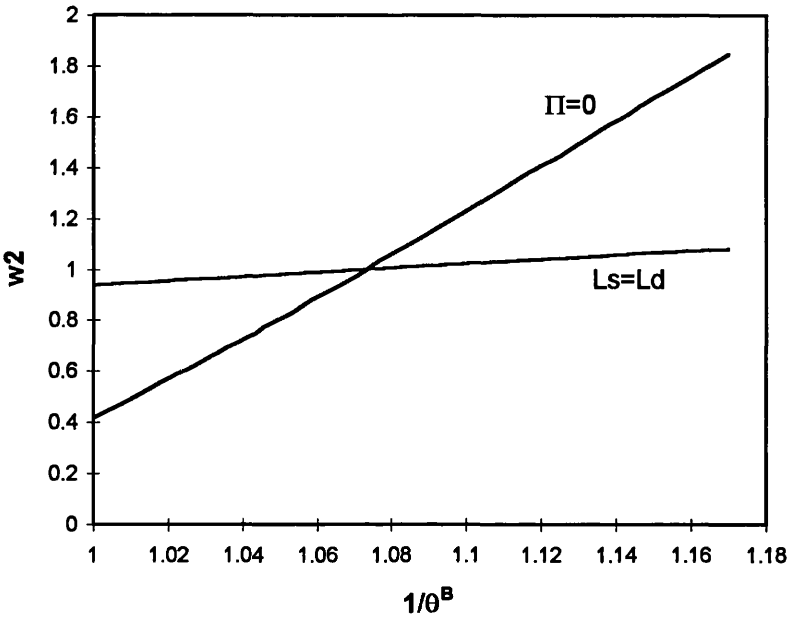


Figure 4



2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
w2
Π=0
Ls=Ld
1
1.02
1.04
1.06
1.08
1.1
1.12
1.14
1.16
1.18
1/θ^B

Figure 5

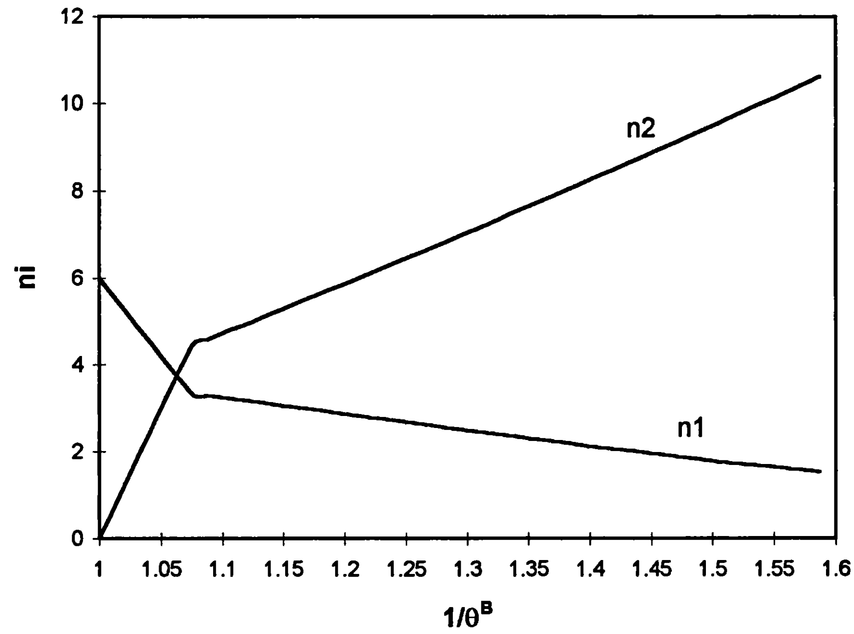
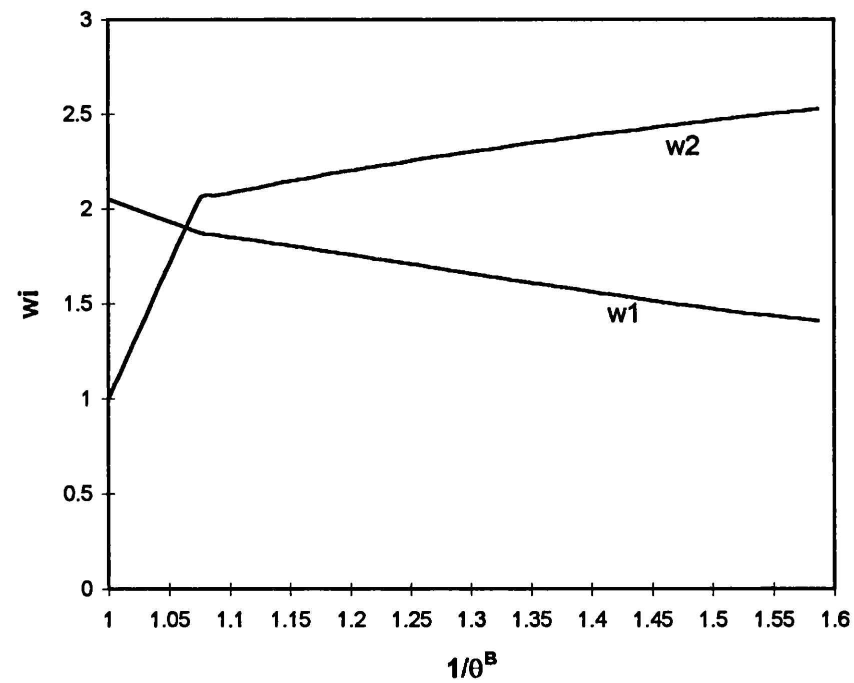


Figure 6



APPENDIX 1

1. To calculate the elasticity of derived demand, equation (9), totally differentiate equations (1), (5) and (6), setting $Y^d = m_1y_1 + m_2y_2$ in equation (1):

$$dp = -\frac{m_1 p^{\eta+1}}{\eta} dy_1 \tag{A1}$$

$$dp = \mu(w_1\theta)^{1-\mu} q_1^{\mu-1}(a+2by_1)dq_1 + (w_1\theta)^{1-\mu} q_1^{\mu} 2bdy_1 \tag{A2}$$

$$dX_1 = (\mu-1)\mu(w_1\theta)^{1-\mu} q^{\mu-2}(f+ay_1+by_1^2)m_1dq_1 + \mu(w_1\theta)^{1-\mu} q^{\mu-1}(a+2b_1)m_1dy_1 \tag{A3}$$

Substitute in for dp from equation (A1) into (A2) and then substitute in for dy_1 in equation (A3) to get:

$$\epsilon_i = \frac{dX_i}{dq_i}\frac{q_i}{X_i} = (1-\mu+\frac{\mu\eta(a+2by_i)^2(m_iy_i+m_jy_j)}{(f+ay_i+by_i^2)[(a+(1+\eta)2by_i)m_i+\eta 2bm_jy_j]}) \tag{A4}$$

2. The two equations in Figure 1 are derived as follows:

Labour supply equals labour demand (equation (12)).

$$w^{\lambda} = (1-\mu)w^{-\mu}(\theta^A)^{1-\mu} q^{\mu} 3fm + F\theta^A n + \beta x \theta^A n \tag{A5}$$

Substituting out for x, y, and q from equations (8), (10) and (14) we have:

$$w^{\lambda}=(1-\mu)w^{-\mu}\theta^{1-\mu}3fm(\frac{\theta^{A}\beta wn\epsilon}{n\epsilon-1})^{\mu}+\beta\theta^{A}\mu(w\theta^{A})^{1-\mu}3fm(\frac{\theta^{A}\beta wn\epsilon}{n\epsilon-1})^{\mu-1}+F\theta^{A}n \quad \text{(A6)}$$

with the number of downstream firms given by setting equation (18) equal to p, with q substituted out using equation (8):

$$m=[(w\theta^{A})^{1-\mu}(\frac{\theta^{A}\beta wn\epsilon}{n\epsilon-1})^{\mu}3f]^{-\eta} \quad \text{(A7)}$$

Substituting in for m into equation (A6) gives us the labour supply equals labour demand function in Figure 1.

The maximum wage which gives zero profit to upstream firms is from equation (22):

$$(q-\beta\theta^{A}w)x=F\theta^{A}w \quad \text{(A8)}$$

Substituting out for q, x using equations (8) and (10), and using $p=m^{-(1/\eta)}$:

$$\mu m^{\frac{\eta-1}{\eta}}=Fn^{2}\theta^{A}w\epsilon \quad \text{(A9)}$$

with m determined from equations (A6) and (A7), so the number of downstream firms is a function of the labour clearing wage. Equation (A9) gives the maximum wage upstream firms can afford to pay.

APPENDIX 2

The simulations of the model have the following parameter values:

Figures 1, 2, 3, 4, 5 and 6

μ=.6; a=b=f=.05; F=.5; β=1; η=5; λ=5; θ^A=1;

Figure 2

A shift from η=5 to η'=6.

Figure 3

A shift from λ=5 to λ'=6.

CHAPTER 3

SPECIALISATION PATTERNS IN EUROPE

Have specialisation patterns in the European Union (EU) changed? The process of dismantling trade barriers between member countries began in 1957 with the formation of the EU[1] and has continued to date. It has involved removing tariffs on goods traded between member countries and reducing non-tariff barriers by harmonizing product standards and simplifying government formalities. According to all strands of trade theory, reducing trade costs should lead to an increase in the degree of specialisation. However, there are three strands of literature which have distinct predictions about specialisation patterns. First, the classical Heckscher-Ohlin theory determines each country will specialise in industries which are intensive in the factors which it is abundantly endowed. Second, the new trade theories show that each country will produce less product varieties within an industry to take advantage of increasing returns to scale, Krugman (1979). And third, the new economic geography theories show that vertical linkages between industries will result in the agglomeration of these industries in the one location, Krugman and Venables (1995) and Venables (1996a).

The purpose of this Chapter is to analyse whether specialisation has increased in

[1] The European Union was formed in 1957. The first countries to form the EU were Belgium, Germany, France, Italy, Luxembourg and Netherlands. The EU was expanded to include Denmark, Ireland and the United Kingdom in 1973; Greece in 1981; and Spain and Portugal in 1986. Austria, Finland and Sweden joined in 1994 - these countries are not included in this study since the data ends in 1990.

EU countries, and to determine whether specialisation patterns are consistent with trade theories. Analysing whether specialisation has increased is one way to ascertain whether expected gains from trade have been realised. These gains arise from allocating production according to comparative advantage and thereby achieving a more efficient allocation, by enabling firms to expand production to exploit economies of scale, and from the pecuniary externalities which arise from vertically linked industries locating close to each other. To see whether specialisation has increased in Europe, I construct country specialisation indices and geographical concentration indices. The movements in the country specialisation indices provide a picture of whether countries have become more different from each other in their industrial structures. The geographical concentration indices provide a picture of which industries are the most concentrated, which enables us to study the characteristics of these industries and hence determine whether the specialisation patterns are consistent with the trade theories.

I utilise production data to construct indices of specialisation for each EU country and for each manufacturing industry, and then see how these indices evolve over time. I regress the geographical concentration indices on three variables, each representing one of the three strands of trade theory: (i) a measure of the deviation of labour intensity from the average, to proxy the Heckscher-Ohlin theory; (ii) scale economies, to proxy the 'new' trade theory; and (iii) the degree of intermediate goods in production, to proxy the economic geography theory. I draw from two data sets: one includes 65 manufacturing industries in Belgium, France, Germany, Italy and the United Kingdom for the period 1976 to 1989; the second is more aggregated with 28 manufacturing industries but includes all of the EU countries except Luxembourg and it begins in 1968.

Empirical studies on specialisation patterns in Europe have produced conflicting results. Aquino (1978) suggests that specialisation in Europe has fallen or remained constant over the period 1951 to 1974, and Sapir (1996) finds that specialisation remained constant over the period 1977 to 1992 in Germany, Italy and the United Kingdom, and increased in France since 1986. In contrast, Hine (1990) and Greenaway and Hine (1991) show that specialisation increased in Europe, at least during the period 1980 to 1985. These mixed results could be due to the different variable adopted, the level of aggregation or the differences in the measures of specialisation. Aquino (1978) and Sapir (1996) use exports, Hine (1990) uses production, and Greenaway and Hine (1991) use exports and production. All the studies include around 28 manufacturing industries except Sapir (1996) which has 100 industries. Increasing specialisation should be evident whether it is measured in terms of production or trade data. However, in practice the link between trade and production may not be as direct as in theory. An advantage of the present study is that it has the highest level of disaggregation for production data.

These empirical studies have raised a number of measurement issues. In particular, which data sources should we use, national or trade data?; which level of aggregation?; and how should we measure specialisation? In section 1 of this Chapter, I discuss these measurement issues and I propose a new index of specialisation which overcomes some of the problems inherent in existing measures. In section 2, I show that there is evidence of increasing specialisation in some of the EU countries. In section 3, I identify which industries became more geographically concentrated and show that there is some support for all three strands of the trade theories, but only weak support for the Heckscher-Ohlin theory. Section 4 concludes. The full results are contained in the Appendix.

1. MEASURING SPECIALISATION

International trade theories predict that reducing trade costs will increase trade volumes, providing a vehicle for countries to move resources into industries in which they have a comparative advantage, thereby increasing the volume of world production. So a reduction in trade costs should lead each country to become more different from its trading partners in terms of their industrial structures - different industries become more geographically concentrated in different countries. If the country specialisation indices increase, we should also expect to see an increase in some of the geographical concentration indices as the two are obviously related. The issues relating to measuring country specialisation also apply to measuring geographical concentration since both are constructed in the same way. The only difference in their construction is that we aggregate across industries to get a measure of country specialisation and aggregate across countries to get a measure of geographical concentration. Therefore, I will discuss the measurement issues in relation to the country specialisation index and only make reference to the geographical concentration index as required.

In theory, an increase in specialisation should be evident whether it is measured by export or production data. However, in practice exports may increase without any change in the volume of production due to a fall in domestic consumption. Sapir (1996) uses export data to measure specialisation because that data set is more complete. However, it seems worthwhile to go to the direct source of our interest, that is production, even at the cost of excluding industries for which the data set is incomplete. The EUROSTAT data set in my study covers 65% of the manufacturing sector. The level of aggregation and the way industries are classified is usually dictated by the availability of data, and the problems this raises are well known. (See for example Aquino (1978)). The more aggregated the data the less information we are likely to obtain. Therefore, even if the specialisation index remains unchanged, we cannot rule out that changes may have occurred which would only be obvious at a more disaggregated level.[2]

Various indices have been used to measure specialisation. Sapir (1996) uses the Herfindahl index to measure country specialisation, which is defined as:

$$H_j=\sum_i (s_{ij})^2 \tag{1}$$

where s_{ij} is industry i's share in total exports (or production) of country j. A value close to one implies almost complete specialisation in one industry and a value close to zero implies a high degree of diversification.

I will refer to the H_j index as a measure of 'absolute specialisation' since it indicates how different the distribution of production shares is from a uniform distribution. This index could change for reasons unrelated to changes in trade costs. For instance, consumer preferences may change or there may be a technological shock in a particular industry which affects all countries in the same way. If there were a technological shock in electronics and this industry had a low production share before the shock then the H_j index would fall indicating a fall in specialisation whereas if it had a high production share before the shock then the H_j index would increase indicating an increase in specialisation. But a skewed distribution towards one industry is also consistent with autarky and may have nothing to do with the level of trade costs. Trade theories predict that a fall in trade costs will lead to each country becoming more different from its trading

[2] Note that the main focus of many of the empirical papers is to distinguish between the extent of inter and intra-industry trade specialisation. I will not categorise specialisation in this way. To do so would require a higher level of disaggregation of the data (which is not available for production) and then a categorisation according to an economic definition of an industry.

partners. Therefore, to see whether the European experience is consistent with the trade hypothesis, it is preferable to construct an index of what I call 'relative specialisation', which measures how different a country's distribution of production shares is from its trading partners' distribution of shares.

Various measures of relative specialisation have been utilised in empirical studies, each differing in their construction and, in particular, on the weighting assigned to countries and industries. I discuss some of the commonly used measures of relative specialisation and show how the weights assigned to countries and industries can bias the movements in the indices. Special care needs to be taken to ensure that changes in the index are not unduly driven by movements in the smallest countries or the smallest industries in the sample.

A popular index of relative specialisation is the Finger-Kreinin index (F-K), defined as:

$$F_{jk}=\sum_i \min(s_{ij},s_{ik}) \tag{2}$$

where the subscripts k and j refer to two different countries. The index ranges between zero and one: if the distribution of shares in both countries is identical then the index is equal to one and if the countries have completely disjoint production patterns then the index is equal to 0.[3] Interpreting changes in the F-K index is straightforward when there are only two countries in the sample.

[3] The F-K index is also known as the Michaely index. The F-K index is a transformation of the Krugman (1991b) index, where the Krugman index is equal to $\sum_i | s_{ij} - s_{ik} |$ and the F-K index is equal to $1-½ \sum_i | s_{ij} - s_{ik} |$. The Krugman index lies between 0 and 2. Krugman (1991b) compares the degree of specialisation in four EU countries with similarly sized American regions using employment data and found that the EU countries were less specialised than American regions.

But suppose there are three countries and the index falls from one period to the next for country j compared to country k but increases for country j compared to country s. Can we then conclude that specialisation in country j has increased? The answer is that we do not know. Unless the index for country j compared to all the countries in the sample moves in the same direction we cannot say what has happened to the degree of specialisation in country j.

Hine (1990) and Greenaway and Hine (1991) obtain a summary measure of the F-K index by taking the mean of the bilateral comparisons in a sample of 21 OECD countries. Greenaway and Hine (1991) take the mean of the bilateral comparisons between country j with all other countries in the sample and report a summary measure for each country. Since the mean of each country's index fell in the early 1980's, Greenaway and Hine (1991) conclude that there has been greater inter-industry specialisation in production during this period. Hine (1990) averages bilateral comparisons between groups of countries and concludes that inter-industry specialisation increased in the EU countries, which include Belgium, Denmark, Germany, Ireland, Italy, Netherlands and the UK. The mean of the F-K index is not a satisfactory summary measure of specialisation as large variations in small countries' production shares could easily drive the value of the index. To illustrate, suppose there are three countries with two industries which have the following production patterns:

t=1:	industry output			industry shares		mean F-K
	1	2	total	1	2	
country 1	5	5	10	.5	.5	.9
2	60	40	100	.6	.4	.85
3	80	120	200	.4	.6	.85
total	145	165	310	.47	.53	

t=2:	industry output			industry shares		mean F-K
	1	2	total	1	2	
country 1	0	10	10	0	1	.5
2	50	50	100	.5	.5	.75
3	100	100	200	.5	.5	.75
total	150	160	310	.48	.52	

It seems clear that in period 2 relative specialisation increased in country 1, and decreased in countries 2 and 3 as they are closer to the average distribution of shares. Yet according to the mean of the F-K index specialisation increased in all countries. (The lower the index the higher the degree of specialisation).

Other popular specialisation indices aggregate the Balassa (1965) index in various ways. The Balassa index, originally designed to measure a country's 'revealed' comparative advantage using export data, is defined as:

$$B_{ij}=\frac{s_{ij}}{w_i} \tag{3}$$

where s_{ij} is industry i's share in total production of country j, and w_i is the share of industry i in the world's total manufacturing production (or in our study, in the EU). If a country's production structure matches that of the average of all other countries then the index is equal to one. An index greater than one reflects specialisation in that industry. The Balassa index has no upper bound and the lower limit is zero. A ratio of shares is likely to result in high values for industries which account for small shares of world production, small w_i's.[4]

[4] Kol and Mennes (1986) discuss some problems with the Balassa index as a measure of similarity of trade patterns.

Hence, variations in small industries can unduly affect a summary measure using the Balassa index. An alternative to taking the ratio of the shares is to subtract the denominator from the numerator of the Balassa index, thus giving less weight to the small industries. But we still need some satisfactory way to aggregate across the industries (or across countries for geographical concentration indices) in order to provide a summary measure of relative specialisation.

An approach, borrowed from the inequality literature, is to calculate the Gini.[5] For the country specialisation Gini, first construct a Lorenz curve as follows: rank the Balassa index in descending order; plot the cumulative of the numerator on the vertical axis against the cumulative of the denominator on the horizontal axis. The Gini is equal to twice the area between a 45 degree line and the Lorenz curve. If the industrial structure of country j matches the industrial structure of the average of Europe, the Gini will equal zero. The higher the Gini, the more specialised is the country. (Analogously, we can construct a Gini for each industry to measure geographical concentration by rewriting the Balassa index as $B_{ij}=p_{ij}/w_j$ where p_{ij} is country j's production of industry i as a proportion of total European production of industry i, and w_j is country j's share of manufacturing in total European manufacturing). The Gini places implicit relative value on changes in the middle parts of the distribution, so a transfer from a big industry to a small industry has a much greater effect on the country Gini if the two

[5] Krugman (1991b) uses the Gini to determine the degree of geographical concentration of industries in the United States. Brulhart and Torstensson (1996) use the Gini in a study of 18 industries in 11 EU countries and found that geographical concentration has increased between 1980 and 1990. Helg et al (1995) use the Gini to measure geographical concentration of industries and country specialisation in the EU. In their country specialisation measure they only use shares (the numerator of the Balassa index) which means they are comparing the distribution of shares to a uniform distribution and not to the distribution of the average of the countries, which is a measure of absolute specialisation.

industries are near the middle rather than at either end of the distribution. (See Cowell (1995) for a discussion of problems related to the Gini). This means that movements between industries which are the closest to the European average will get the most weight in the country Gini. As these industries may vary from year to year, the weighting of industries will also vary and we do not know whether these will be the big or small industries.

An alternative approach to constructing a summary measure of specialisation is to calculate the standard deviation of the Balassa index. The use of the standard deviation (or the variance) as a measure of changes in distribution is common in the inequality and the economic growth convergence literature. Aquino (1978) calculates the standard deviation of the Balassa index weighted by industry shares to get a measure of country specialisation, σ_j, and the standard deviation weighted by country shares to get a measure of industry specialisation, σ_i. An increase in the standard deviation indicates an increase in specialisation. Aquino (1978) concludes that inter-industry specialisation in 26 OECD countries has been limited over the period 1951 to 1974 with a tendency towards a further reduction in inter-industry specialisation. The weighted standard deviation helps to reduce the small country and small industry influence inherent in the Balassa index. In the country specialisation index, an equal transfer from one industry to another, $ds_1 = -ds_2 = ds$, with the weights constant, would change the index as follows:

$$\frac{d\sigma_j}{ds}\sigma_j = \left(\frac{s_1}{w_1} - \frac{s_2}{w_2}\right) \tag{4}$$

Even with this weighting, it is clear that transfers among industries with the smallest w_i's are likely to have the biggest influence. To reduce this bias, I construct an index similar to a standard deviation:

$$S_j = \sqrt{\frac{1}{n}\sum_i (s_{ij} - w_i)^2} \tag{5}$$

Equation (5) subtracts the denominator from the numerator of the Balassa index thus avoiding the problem of giving too much weight to small industries. Squaring ensures all the industries get a positive weight in the measure, with those industries furthest away from the European average receiving the most weight. A transfer from industry 2 to industry 1, assuming the weights remained unchanged, would affect the index in the following way:

$$\frac{dS_j}{ds} S_j = \frac{1}{n}[(s_1 - w_1) - (s_2 - w_2)] \tag{6}$$

In sum, the F-K may be an unsuitable measure of specialisation if the changes in bilateral comparisons do not move in the same direction; the Gini could give too much weight to the 'wrong' industries; a weighted standard deviation goes some way in giving the 'correct' weights; and the S_j index is an alternative way of ensuring that small industries or countries are not weighted too heavily.

2. SPECIALISATION IN THE EU COUNTRIES

I utilise two databases to investigate whether the degree of specialisation has increased in EU countries. I construct measures of specialisation for each country using the S_j, H_j, σ_j, G_j and F-K_j indices with production data. I also construct indices using employment data to check for consistency. According to trade theories an increase in the degree of specialisation should be evident whether measured by production or employment.

DATA

The first data set is from EUROSTAT: It consists of 65 manufacturing industries classified according to NACE3, for Belgium, France, Germany, Italy and the UK. The other manufacturing industries and countries in the database were not included due to too many missing values. The data set represents approximately 65% of the total manufacturing output in these five countries. It is annual data covering the period 1976 to 1989. This was the most disaggregated production and employment data available.

In order to study specialisation patterns over a longer period and in more of the EU countries we turn to the UNIDO data set. It consists of only 28 manufacturing industries, classified according to ISIC3, for 11 European Union countries: Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain and the United Kingdom. It is annual data covering the period 1968 to 1990.

From Figures 1 and 2 we can get an indication of the relative size of the countries. Figures 1a and 1b are a plot of the value of manufacturing production for each country as a proportion of the total manufacturing production in the EU and Figures 2a and 2b are a plot of the employment shares in manufacturing. In terms of production value, Germany has the largest manufacturing share (more than 30 per cent), followed by France, UK, and Italy, with a rise in Italy's share and a fall in the UK's share; Belgium, Spain and Netherlands are next with Spain's share increasing, and Belgium's and Netherlands' falling; and the smallest countries are Denmark, Portugal, Greece and Ireland with each having shares less than .02 per cent. The ordering changes when we rank the countries according to employment shares. Germany is still the largest, with an increasing share over the period, followed by UK with a falling share, and then France, and Italy with relatively constant shares. The value of production in manufacturing increased in all five countries whereas employment fell in all of the countries.

EUROSTAT

The relative specialisation indices[6] using the EUROSTAT data set with production and employment are listed in Tables 1(a) to 1(j) of the Appendix.[7] They all indicate an increase in specialisation in all of the five countries over the period 1976 to 1989, except the increase in the Gini with employment for Italy was not significant at the five per cent level. In fact, the F-K_j fell for all bilateral comparisons, except for Italy and Germany with employment data, indicating an increase in specialisation. I regressed the log of each index on a time trend to determine the growth rate of the indices. The S_j index is given in Table 1 below, showing an average annual increase of two per cent.

TABLE 1: S_j index - production

	1976	1980	1982	1984	1986	1989	beta	t value
UK	0.40	0.54	0.57	0.57	0.59	0.62	0.03	6.10
Bel	0.76	0.93	0.99	1.00	0.93	1.04	0.02	5.48
Ita	0.54	0.63	0.64	0.58	0.62	0.65	0.01	3.08
Fra	0.62	0.64	0.66	0.67	0.75	0.77	0.02	10.82
Ger	0.45	0.42	0.46	0.50	0.56	0.57	0.02	8.74

The correlation between the measures is given in Table 2 below. It is not surprising that the correlation between the Herfindahl index and all the other

[6] All the indices are multiplied by 100.

[7] The UK reclassified its manufacturing industries in 1979. To check that the reclassification is not driving the results, I re-calculated all the indices excluding the UK and found that specialisation increased in the remaining four countries.

measures is low since the H_j index is a measure of absolute specialisation and all the others are measures of relative specialisation. The correlations between all of the measures of relative specialisation are quite high.

TABLE 2: CORRELATION BETWEEN DIFFERENT MEASURES

	F-K_j	G_j	σ_j	S_j
H_j	.47	.57	.54	.61
F-K_j		.80	.81	.84
G_j			.99	.97
σ_j				.94

UNIDO

With the UNIDO data, the results vary with the index and the variable.[8] All of the values of the indices, with the beta and t values, are reported in Tables 2(a) to 2(j) of the Appendix to this Chapter and some of the S_j values are reported in Tables 3(a) and 3(b) below. According to the S_j index using production, specialisation increased in Belgium, Denmark, Greece and Italy; decreased in France, Ireland, Portugal, Spain and the UK; and remained unchanged in Germany and Netherlands. The S_j index with employment data shows that specialisation increased in Belgium, Denmark, France, Germany, Greece and Netherlands; decreased in Ireland and Spain; and there was no significant change in Italy, Portugal and UK. The Gini shows the same pattern as the S_j index.

[8] I re-calculated the indices without the UK and found the results did not change.

Table 3a: S_j index with Production

	1968	1975	1978	1981	1984	1990	beta	t value
Bel	1.65	1.71	1.80	1.84	1.84	2.18	0.01	8.14
Den	2.94	3.06	4.05	3.92	4.04	3.73	0.01	5.45
Fra	0.98	0.80	0.74	0.66	0.70	0.64	-0.02	-7.22
Ger	1.12	1.23	1.17	1.13	1.25	1.26	0.00	1.94
Gre	2.90	2.92	3.05	3.18	3.36	3.58	0.01	13.95
Ire	4.65	5.59	5.37	4.60	4.24	4.43	-0.01	-2.34
Ita	0.94	0.86	0.98	1.09	1.16	1.29	0.02	9.52
Net	2.54	2.61	2.88	2.84	2.78	2.54	0.00	1.05
Por	3.50	3.23	2.72	2.79	2.85	3.16	-0.01	-2.49
Spa	1.67	1.93	1.29	1.28	1.51	1.55	-0.01	-2.86
UK	0.92	0.66	0.60	0.56	0.40	0.54	-0.02	-6.07

Table 3b: S_j index with Employment

Bel	1.46	1.53	1.44	1.44	1.55	1.58	0.003	2.05
Den	1.79	2.02	2.30	2.39	2.33	2.27	0.01	8.00
Fra	0.52	0.53	0.52	0.50	0.61	0.67	0.01	3.64
Ger	1.31	1.43	1.28	1.27	1.37	1.54	0.01	3.73
Gre	3.30	3.30	3.30	3.39	3.49	3.70	0.001	9.71
Ire	3.90	3.84	3.50	3.18	3.13	2.72	-0.02	-19.99
Ita	1.28	0.98	0.98	1.05	1.12	1.29	0.003	0.97
Net	1.56	1.72	1.95	2.04	2.06	1.92	0.01	6.92
Por	4.99	3.90	3.70	3.76	3.86	4.24	-0.005	-1.95
Spa	2.06	2.01	1.55	1.47	1.49	1.74	-0.01	-4.29
UK	0.65	0.59	0.53	0.59	0.57	0.61	-0.002	-1.52

From Tables 4a and 4b below, we see that the weighted standard deviation of the Balassa index with production and employment data also indicates that there was a significant fall in specialisation in Ireland, Spain and the UK, and additionally in Belgium.

Table 4a: σ_j index with Production

	1968	1975	1978	1981	1984	1990	beta	t value
Bel	37.95	35.61	35.95	33.86	34.79	35.20	-0.004	-4.64
Den	40.32	44.27	49.73	50.01	52.29	48.03	0.01	5.42
Fra	27.27	25.03	27.03	25.49	26.03	27.98	0.00	0.36
Ger	38.72	42.74	43.09	41.37	42.43	44.42	0.004	4.06
Gre	51.78	53.88	59.38	57.85	65.48	67.63	0.02	12.61
Ire	66.48	72.77	65.81	60.98	61.66	60.70	-0.01	-5.08
Ita	37.68	36.09	39.58	40.69	40.37	44.01	0.01	8.17
Net	33.93	38.39	41.11	45.13	43.99	41.68	0.01	7.47
Por	60.29	52.81	48.75	54.16	52.37	57.78	0.00	0.52
Spa	38.45	44.89	25.47	23.77	26.78	29.30	-0.03	-4.26
UK	37.26	30.33	31.22	29.40	25.27	29.49	-0.01	-5.03

Table 4b: σ_j index with employment

	1968	1975	1978	1981	1984	1990	beta	t value
Bel	34.92	34.39	34.04	32.05	33.66	32.41	-0.01	-7.41
Den	37.05	39.04	40.61	41.91	41.88	43.69	0.01	13.38
Fra	28.03	28.32	27.41	25.51	27.39	28.01	0.00	-1.88
Ger	48.22	48.69	45.42	44.87	46.09	50.21	0.00	0.62
Gre	56.19	49.38	51.63	55.31	58.19	65.25	0.01	6.43
Ire	58.44	58.87	52.07	47.33	49.40	44.95	-0.01	-11.12
Ita	32.48	33.01	34.32	34.87	36.25	38.85	0.01	15.30
Net	32.50	34.99	40.97	43.84	45.08	43.51	0.02	10.64
Por	76.39	66.14	63.24	67.29	72.20	82.98	0.005	1.84
Spa	33.89	37.80	25.41	24.84	24.74	26.10	-0.02	-5.36
UK	35.11	29.39	28.20	26.68	24.13	23.39	-0.02	-22.8

Table 5 summarises the change in each index from 1968 to 1990 with UNIDO data, where P denotes production data, L denotes employment data, (+) indicates a significant increase in the index, (-) a significant decrease in the index, and (0) indicates that there has been no significant change. Table 6 reports the correlation between the indices.

TABLE 5: 1968 to 1990

	UNIDO									
	FK_j		G_j		σ_j		S_j		H_j	
	P	L	P	L	P	L	P	L	P	L
Bel	+	-	+	0	-	-	+	+	+	0
Fra	+	0	-	+	0	0	-	+	0	+
Ger	+	+	+	+	+	0	0	+	+	+
Ita	+	+	+	+	+	+	+	0	-	+
UK	0	-	-	-	-	-	-	0	+	0
Den	+	+	+	+	+	+	+	+	+	+
Gre	+	+	+	+	+	+	+	+	0	+
Ire	0	-	-	-	-	-	-	-	0	+
Net	+	+	+	+	+	+	0	+	0	-
Por	0	0	0	0	0	0	-	0	-	-
Spa	-	-	-	-	-	-	-	-	+	0

TABLE 6: CORRELATION BETWEEN DIFFERENT MEASURES

	$F\text{-}K_j$	G_j	σ_j	S_j
H_j	.02	.64	.72	.63
$F\text{-}K_j$		.02	.01	.01
G_j			.90	.96
σ_j				.86

The bilateral comparisons for each country using the $F\text{-}K_j$ do not move in the same direction using the UNIDO data so it is not a reliable measure of specialisation. This shows up in the low correlation between the $F\text{-}K_j$ and the other indices. The H_j also has a fairly low correlation with the other indices which is not surprising since it is measuring absolute rather than relative specialisation. Consequently I will focus on the results of the other three measures: the S_j, G_j and σ_j.

At least two of the three measures, with production and employment, indicate that specialisation increased in Denmark, Greece, Germany, Italy and Netherlands. And all three measures indicate that specialisation fell in Ireland, Spain and UK, and that there was no significant change in Portugal. Why might the degree of specialisation in a country fall? One possible explanation is that before joining the EU, the countries may have had high trade barriers protecting industries in which they did not have a comparative advantage. The elimination of trade barriers within the EU increased competitive pressures to increase production in the industries in which each country has a comparative advantage. All of these countries are late joiners to the EU and even though specialisation fell when comparing 1968 to 1990, there is an upward trend starting in the late 1970's and early 1980's in Portugal, Spain and UK. This becomes clear for the UK when we compare the results from EUROSTAT and UNIDO for the same period in Table 7 below. We see that both data sets indicate an increase in specialisation in the UK between 1976 and 1989.

TABLE 7: 1976 to 1989

	EUROSTAT										UNIDO									
	FK_j		G_j		σ_j		S_j		H_j		FK_j		G_j		σ_j		S_j		H_j	
	P	L	P	L	P	L	P	L	P	L	P	L	P	L	P	L	P	L	P	
Bel	+	+	+	+	+	+	+	+	+	+	+	0	+	+	+	0	+	+	+	+
Fra	+	+	+	+	+	+	+	+	+	-	+	+	0	+	0	+	0	+	0	+
Ger	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+
Ita	+	+	+	0	+	+	+	+	-	-	+	+	+	+	+	+	+	+	0	+
UK	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	0

Even if the specialisation indices with the UNIDO data have not increased, we cannot rule out the possibility that specialisation has increased but is only obvious with more disaggregated data. This is clear in the case of France where all the measures of relative specialisation using the EUROSTAT data indicate an increase in specialisation for all countries whereas some of the measures using the UNIDO data indicate that there has been no significant change in specialisation.

3. GEOGRAPHICAL CONCENTRATION OF INDUSTRIES IN THE EU COUNTRIES

We saw that specialisation has increased in some EU countries since 1968. This means that some industries must have become more geographically concentrated in some countries. We can identify these industries by constructing geographical concentration indices. The S_i index is defined as:

$$S_i=\sqrt{\frac{1}{c}\sum_j (p_{ij}-w_j)^2} \tag{7}$$

where c is the number of countries, p_{ij} is country j's production of industry i as a proportion of total European production of industry i, and w_j is country j's share of manufacturing in total European manufacturing. An increase in S_i indicates that industry i has become more geographically concentrated which means that some countries have increased their production of industry i more than the increase in their total manufacturing, relative to the rest of Europe.

Tables 3a and 3b of the Appendix list the S_i index with production data from EUROSTAT and UNIDO, ranked in descending order based on the first years observations. The industries with the highest S_i index in the EUROSTAT set are:

toys and sports, bread and flour, and paint, wood and wool industries; and those with the lowest S_i index are iron and steel, and processing of plastics. The industries with the highest S_i index in the UNIDO set are: miscellaneous petroleum and coal products, pottery, china and earthenware, and tobacco; and those with the lowest are paper and products; and fabricated metal products.

From Tables 4a and 4b in the Appendix we can see which industries experienced the highest growth in specialisation. The tables list the S_i geographical concentration indices with production data from EUROSTAT and UNIDO, grouped according to the following categories: positive significant growth; negative significant growth; and no significant change in the indices.[9] According to the EUROSTAT data, 31 industries recorded an increase in geographical concentration between 1976 and 1989, ranging between 1 and 12 per cent growth annually (cocoa, chocolate and sugar, textile finishing, knitting, and working of stone recorded the biggest increases); 11 industries recorded a fall in geographical concentration, ranging between 1 and 13 per cent (manufacturing of concrete for construction recorded the biggest fall); and there was no significant change in geographical concentration in 23 industries. According to the UNIDO data, 10 industries recorded a significant increase in geographical concentration between 1968 and 1990, ranging between 1 and 7 per cent (textiles recorded the biggest increase); 10 recorded a fall, ranging between 1 and 6 per cent (plastic products recorded the biggest fall); and no significant change in 8 industries. (Since there is a 98 per cent correlation between the S_i and the G_i indices, I only report the S_i indices). We see that there is some evidence of increasing specialisation and this is more obvious with the disaggregated EUROSTAT data.

[9] Without the UK, the groupings with the UNIDO data remain unchanged however with the EUROSTAT data 6 out of the positive and significant growth industries were not significant when UK was excluded and manufacturing of agricultural machinery changed sign.

Although all trade theories predict that a reduction in trade barriers leads to an increase in specialisation, there are three strands of trade theories which have distinct predictions about the pattern of specialisation. I regress the geographical concentration indices on three variables which are meant to proxy the three strands of trade theories.

According to the new trade theories, reducing trade barriers leads to an increase in specialisation in industries which are subject to economies of scale. Krugman (1979) shows that when countries move from autarky to free trade the number of varieties of goods in each country falls, enabling firms to slide down their average cost curves. So there are gains from trade due to the lower unit cost of production and consumers have access to more varieties through trade. In order to try to capture this effect, I construct a variable, X_{1it}, to proxy scale economies. X_{1it} is defined as labour divided by the number of enterprises. So we would expect that industries which are subject to high scale economies to be more geographically concentrated.

The Heckscher-Ohlin theory predicts that countries will specialise in industries which are intensive in the factors which they are relatively abundant. Hence, labour abundant countries will specialise in labour intensive industries and capital abundant countries will specialise in capital intensive industries. Since the geographical concentration index is not specific to each country, I construct a variable which is the deviation of factor intensities from the mean. X_{2it} is defined as labour costs divided by value added, at factor cost, less the mean of total labour costs as a proportion of the mean of the value added at factor cost[10], all squared.

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[10] I dropped the following three industries as they had negative value added: 4110 manufacture of vegetable and animal oils and fats; 4130 manufacture of dairy products; and 4240 spirit distilling.

According to the theory, those industries which have 'high' factor intensities should be the most geographically concentrated. Since the theory does not imply that capital intensive industries will be more geographically concentrated than labour intensive industries, or vice versa, the deviations of labour intensity from the mean is squared. So we would expect that those industries which differ a lot from the mean should be the most geographically concentrated.

According to the economic geography literature, as trade barriers are reduced vertically linked industries are likely to agglomerate in a limited number of locations. Krugman and Venables (1995) and Venables (1996a) show that a large number of downstream firms attracts a large number of upstream firms due to a 'demand linkages', and the more upstream firms in the one location the more intense is the competition thereby reducing the price of upstream goods providing a feedback effect which is referred to as a 'cost linkage.' This feedback effect may also come from downstream firms having access to a bigger variety of differentiated inputs. These demand and cost linkages are stronger the higher is the proportion of intermediate goods in production of final goods. X_{3it} is a proxy for intermediate good intensity, defined as production less value added, divided by production, at market prices. So we should expect that the higher the proportion of intermediate goods, the higher the geographical concentration.

I estimate the following equation with the EUROSTAT data set[11] to see whether the pattern of specialisation in the EU is consistent with any of the three strands of trade theory.

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[11] It was not possible to estimate this equation with the UNIDO data set since value added is measured in factor prices for some countries and market prices for others.

$$S_{it}=\beta_0+\beta_1 X_{1it}+\beta_2 X_{2it}+\beta_3 X_{3it}+\alpha_i+\nu_t+\epsilon_{it} \tag{8}$$

where subscript i denotes industry i and subscript t denotes time. α_i represents industry dummies and ν_t represents time dummies. The time dummies are relative to 1976 and the industry dummies are relative to iron and steel. The industry dummies represent fixed industry effects which are unobservable and the time dummies represent fixed time effects which are not explained by the model. The time dummies may capture reductions in trade barriers such as the harmonisation of product standards and the reduction of government formalities in trade.

The mean and standard deviation of each variable are listed in Table 7a below, and the correlations between the explanatory variables in Table 7b. I estimate four versions of equation (8) using ordinary least squares. The S_{it} index is replaced by the G_{it} index as the explanatory variable to check that the results are not sensitive to the geographical concentration index. The variables are transformed into logs so that the β_i's can be interpreted as elasticities. The disadvantage of the log specification is that adding a constant to any of the variables would change the elasticity so the results could be sensitive to the way the variables are constructed. To avoid this problem, I also estimate the equation with the variables standardised to have zero mean and standard deviation equal to one. An additional advantage of the standardised equation is that it gives us an indication of the relative importance of each variable in explaining the variation in the geographical concentration index. The β_i^2's can be interpreted as an approximation to the percentage of variation in the specialisation index each variable explains. However, it is only an approximation since the correlations between the explanatory variables, although quite low, are not equal to zero. The full results are provided in Tables 5a and 5b of the Appendix and are summarised in Table 8 below.

TABLE 7a:

	mean	standard deviation
S_{it}	0.02	0.01
G_{it}	0.18	0.09
X_{1it}	178.5	166.69
X_{2it}	0.01	0.02
X_{3it}	0.62	0.09

TABLE 7b: Correlations

	X_2	X_3
X_1	0.18	0.11
X_2	0.13	

TABLE 8:

	(i)	(ii)	(iii)	(iv)
dependent variable:	S_i	$\ln(S_i)$	G_i	$\ln(G_i)$
independent variables:				
X_1	0.19 (2.54)	0.35 (3.16)	0.22 (2.96)	0.39 (3.8)
X_2	0.05 (2.04)	1.16 (1.25)	0.06 (2.69)	1.40 (1.64)
X_3	0.32 (4.29)	1.11 (3.85)	0.25 (3.59)	0.92 (3.43)
industry dummies	yes	yes	yes	yes
time dummies	yes	yes	yes	yes
adjusted R squared	0.84	0.82	0.86	0.83
number of observations	868	868	868	868

All the coefficients are positive and significant[12] in the standardised equation, (i) and (iii), whereas β_2 is not significant in the log specification in the equations with S_{ijt} and G_{ijt}. All the specifications indicate that changes in X_1, which is the proxy for scale economies, and X_3, which is a proxy for the economic geography theory, have the biggest effect on geographical concentration. According to the log specification (equations (ii) and (iv)) a one per cent increase in the proportion of intermediate goods in production leads to approximately one per cent increase in geographical concentration; and a one per cent increase in X_1 leads to an increase in geographical concentration of a third of a per cent. In the standardised equations an increase in X_3 by one standard deviation increases S_i by .3 standard deviations, which means that X_3 explains approximately 10% of the variation in S_i (equation (i)); X_3 explains approximately 6% of the variation in G_i; and X_2 explains around 4% of the variation in geographical concentration.

The main difference in the results of the log and standardised specifications is that β_2 is significant in the standardised specification. Even though it is significant, the size of the coefficient is low. An increase of one standard deviation in factor intensities increases geographical concentration by .05 of a standard deviation, which means that approximately .25 per cent of the variation in the specialisation index can be explained by factor intensity differences. Hence there is only little support for the Heckscher-Ohlin theory. This is not surprising since the five countries in the sample are very similar in terms of their relative factor endowments. The Heckscher-Ohlin theory relies on differences in relative factor endowments for trade and specialisation to take place. See Leamer and Levinsohn (1995) for a review of tests of the Heckscher-Ohlin theory.

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[12] I re-estimated all four equations excluding the UK, and then including all countries for a shorter sample period from 1980. I found that the signs of the coefficients remain the same but only X_3 is significant.

Kim (1996) conducts a similar study of the determinants of geographical concentration in the United States using the Gini. He finds support for the Heckscher-Ohlin theory and the new trade theories but does not test for the new economic geography theory. The support the study claims for the Heckscher-Ohlin theory is questionable. The explanatory variable used in Kim (1996) to test for the Heckscher-Ohlin theory is a measure of raw material intensity and is defined as the cost of raw materials divided by value added. But the Heckscher-Ohlin theory does not claim that resource intensive industries will be more geographically concentrated than other factor intensive industries. Instead, it predicts that countries will specialise in industries which are intensive in the factors which they are relatively abundant. The explanatory variable used in Kim (1996) to test for the new trade theory is constructed in the same way as in this Chapter.

Brulhart and Torstensson (1996) also find support for the new trade theories based on scale economies, using the Spearman rank correlation test. They use the Gini to rank the 18 industries in their sample of EU countries and find a high correlation with the ranking of industries according to scale economies based on 'products and production runs' and 'size of establishments'. Scherer (1980) distinguishes between three different types of economies of scale in production: product specific, plant specific and multi-plant economies. Plant size will only capture certain aspects of scale economies.

Nearly all of the industry dummies are positive and significant indicating that there are unobserved fixed industry effects. Therefore, all of the industries are more geographically concentrated than iron and steel, holding everything else constant. The time dummies show an increasing trend beginning in the early 1980's.

If the explanatory variables are considered to be good proxies for each strand of trade theory, then we could conclude that there is some support for the new trade theory based on scale economies and the economic geography theory based on vertical linkages; and only little support for the Heckscher-Ohlin theory which is based on factor proportions.

4. CONCLUSIONS

This Chapter has shown that there is evidence of increasing specialisation in EU countries between 1968 and 1990. International trade theories predict that the industrial structure of each country should become more different from its trading partners as trade costs fall. To determine whether the European experience is consistent with this trade hypothesis, I propose an index of specialisation which is analogous to a standard deviation which measures how different the distribution of production shares in each country is from its trading partners in Europe.

The disaggregated EUROSTAT data set shows that specialisation increased in all five countries between 1976 to 1989: Belgium, France, Germany, Italy and UK. The UNIDO data set shows that there is increasing specialisation in some EU countries over the period 1968 to 1990. According to at least two out of the following three different measures of specialisation using production and employment data - the new index I constructed, the Gini and the weighted standard deviation - there was an increase in specialisation in Denmark, Greece, Germany, Italy and Netherlands and fall in Ireland, Spain and UK, and that there was no significant change in Portugal. Specialisation may fall in countries which had high trade barriers to protect industries in which they did not have a comparative advantage. The elimination of trade barriers within the EU would increase competitive pressures to increase production in the industries in which each country has a comparative advantage. This may explain why late joiners to the EU such as Portugal, Spain and UK, although experienced a fall in specialisation when comparing 1968 to 1990, have an upward trend in specialisation starting in the late 1970's and early 1980's. This is clear for the UK which has positive significant growth in specialisation for the period 1976 to 1989 according to both data sets.

The geographical concentration indices show an increase in concentration in approximately half the industries and the econometric analysis provides some support for the economic geography theories based on vertical linkages and the new trade theories based on scale economies. There was only weak support for the Heckscher-Ohlin theory. This is not surprising since the five countries in the sample are very similar in terms of their relative factor endowments. The Heckscher-Ohlin theory relies on differences in relative factor endowments for trade and specialisation to take place.

This Chapter has only shown that the EU experience is consistent with trade theories. In order to test the theories we need a proper measure of the level of trade costs, preferably for each country and for each industry.

Figure 1a

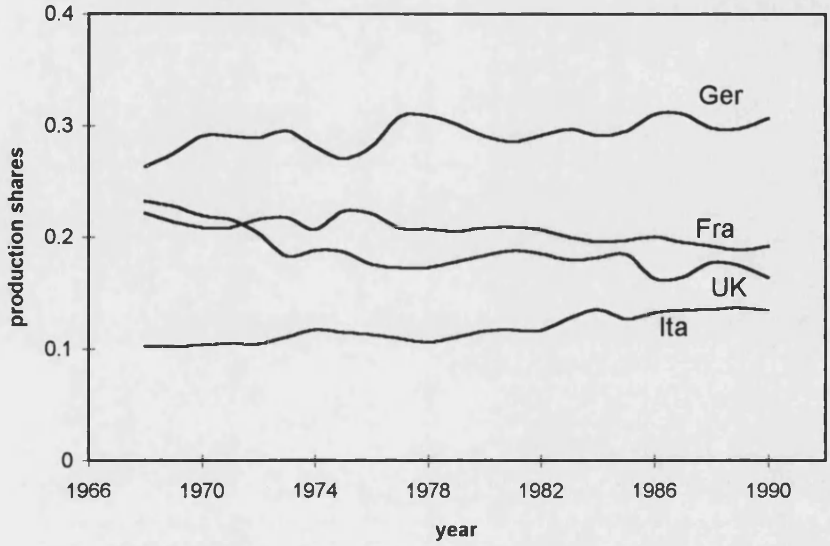


Figure 1b

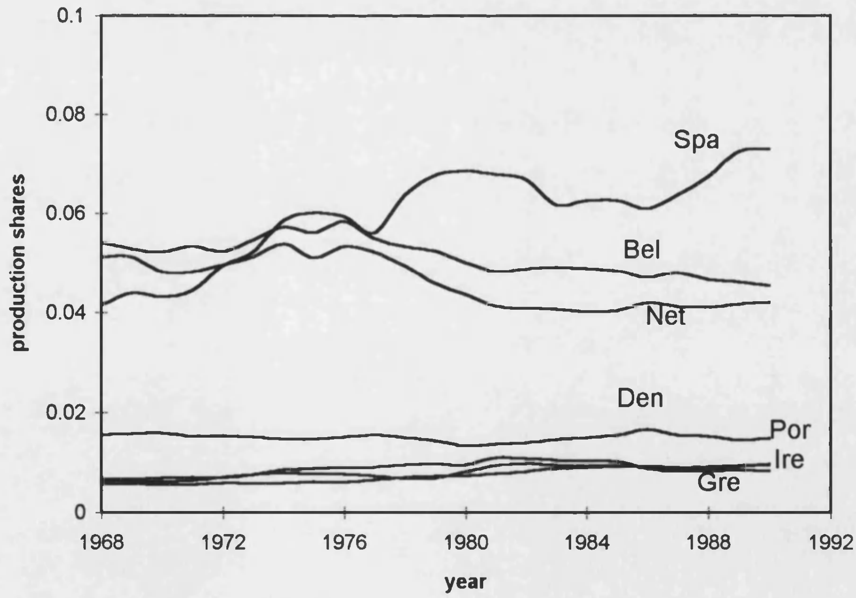


Figure 2a

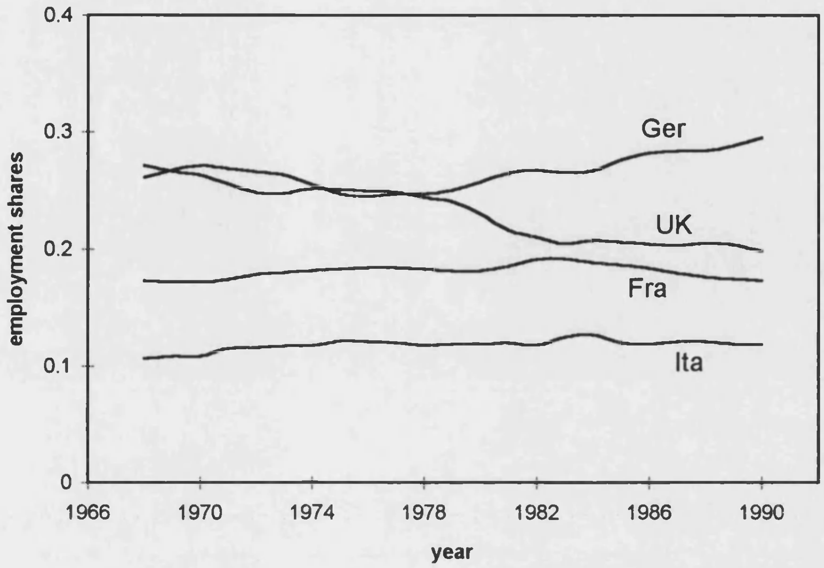
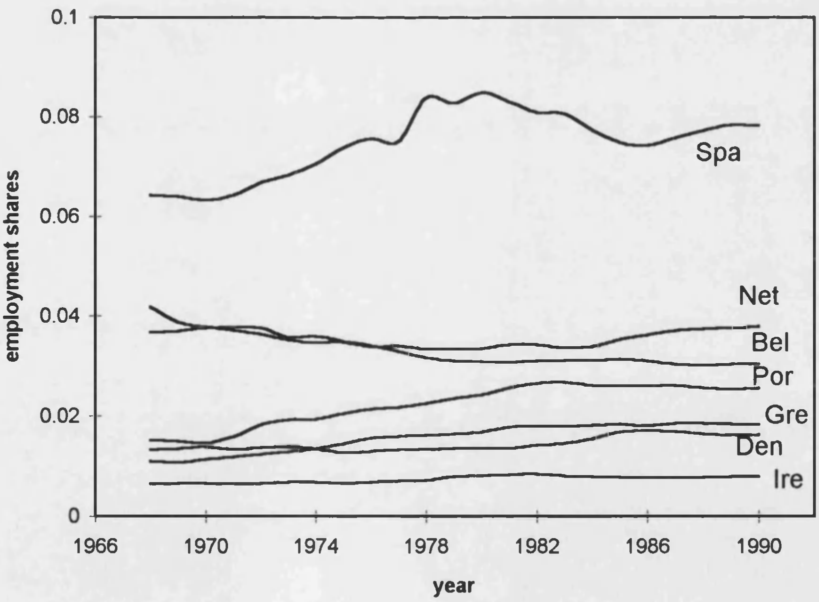


Figure 2b



APPENDIX

Table 1a

Sj with production

	Bel	Fra	Ger	Ita	UK
1976	0.76	0.62	0.45	0.54	0.40
1977	0.73	0.57	0.41	0.54	0.40
1978	0.82	0.60	0.44	0.57	0.40
1979	0.83	0.61	0.46	0.64	0.49
1980	0.93	0.64	0.42	0.63	0.54
1981	0.90	0.65	0.46	0.63	0.54
1982	0.99	0.66	0.46	0.64	0.57
1983	0.99	0.65	0.48	0.62	0.56
1984	1.00	0.67	0.50	0.58	0.57
1985	0.99	0.70	0.53	0.62	0.57
1986	0.93	0.75	0.56	0.62	0.59
1987	0.93	0.74	0.55	0.63	0.57
1988	1.03	0.74	0.57	0.63	0.58
1989	1.04	0.77	0.57	0.65	0.62
β	0.02	0.02	0.02	0.01	0.03
t value	5.48	10.82	8.74	3.08	6.10

Table 1b

Sj with employment

	Bel	Fra	Ger	Ita	UK
1976	0.85	0.50	0.52	0.65	0.42
1977	0.85	0.54	0.50	0.64	0.42
1978	0.84	0.54	0.49	0.63	0.41
1979	0.87	0.54	0.49	0.69	0.49
1980	0.88	0.62	0.47	0.71	0.55
1981	0.89	0.61	0.50	0.72	0.59
1982	1.05	0.63	0.53	0.70	0.64
1983	0.93	0.61	0.55	0.70	0.65
1984	0.94	0.60	0.57	0.67	0.65
1985	0.95	0.63	0.59	0.68	0.64
1986	0.89	0.66	0.60	0.66	0.62
1987	0.87	0.66	0.62	0.70	0.62
1988	0.92	0.69	0.63	0.72	0.62
1989	0.92	0.70	0.62	0.77	0.62
β	0.01	0.02	0.02	0.01	0.03
t value	1.85	9.35	7.43	2.90	5.07

Table 1c

gini with production

	UK	Bel	Ita	Fra	Ger
1976	14.01	24.12	18.18	17.26	13.71
1977	13.89	24.48	18.61	16.80	12.65
1978	13.59	25.84	19.07	17.39	13.05
1979	14.76	26.13	20.62	17.26	13.18
1980	16.06	27.65	20.98	18.18	12.92
1981	16.25	27.45	21.17	18.19	13.89
1982	16.89	30.49	20.87	18.17	13.83
1983	17.47	29.99	20.45	17.90	13.99
1984	17.25	29.49	19.44	18.52	14.55
1985	17.24	29.36	20.38	19.13	15.52
1986	17.92	29.35	19.88	20.28	16.02
1987	17.47	30.25	20.19	20.40	16.02
1988	17.66	31.41	20.28	20.50	16.28
1989	18.08	31.32	20.71	21.01	16.56
β	0.02	0.02	0.01	0.02	0.02
t value	7.89	8.28	1.95	10.63	8.67

Table 1d

gini with employment

	Bel	Fra	Ger	Ita	UK
1976	26.46	17.19	16.22	20.86	13.67
1977	26.53	17.88	15.33	20.65	13.77
1978	26.81	17.95	15.05	20.34	13.61
1979	26.97	17.86	14.97	21.71	15.06
1980	27.63	19.40	14.69	22.06	16.21
1981	27.84	19.42	15.22	22.36	17.52
1982	31.30	19.62	15.81	21.68	18.41
1983	28.95	19.11	16.22	21.26	19.40
1984	29.02	19.01	16.75	20.65	19.07
1985	29.51	19.72	17.23	20.94	18.93
1986	29.39	20.36	17.39	20.55	18.56
1987	29.39	20.59	17.85	21.48	18.61
1988	30.50	21.27	18.10	22.03	18.76
1989	30.55	21.69	17.89	23.01	18.64
β	0.01	0.01	0.01	0.00	0.03
t value	5.70	9.90	5.65	1.50	5.90

Table 1e

σj with production

	Bel	Fra	Ger	Ita	UK
1976	45.76	31.59	25.19	34.18	28.13
1977	48.06	30.42	23.10	35.37	27.55
1978	51.04	31.28	23.46	35.42	27.58
1979	49.37	31.38	23.94	38.34	29.60
1980	54.33	32.87	23.22	38.57	30.93
1981	55.09	32.98	24.86	39.37	32.63
1982	64.09	32.96	24.77	39.06	32.91
1983	59.28	32.46	25.13	39.09	34.62
1984	59.07	33.65	26.06	38.02	34.46
1985	57.90	34.99	27.83	40.24	34.64
1986	59.05	36.65	28.61	38.60	36.00
1987	64.97	37.11	28.61	39.20	34.97
1988	66.14	37.56	29.12	39.70	35.03
1989	66.94	38.62	29.70	40.90	36.11
β	0.03	0.02	0.02	0.01	0.02
t value	8.24	10.52	7.31	4.95	9.12

Table 1f

σj with employment

	Bel	Fra	Ger	Ita	UK
1976	50.12	31.26	29.26	38.25	26.99
1977	50.48	32.41	27.57	37.47	26.74
1978	51.49	32.27	26.91	36.83	26.54
1979	51.63	33.05	26.79	38.91	27.96
1980	54.05	35.64	26.22	39.29	29.83
1981	55.12	35.70	27.22	39.91	32.85
1982	67.17	35.83	28.29	39.11	33.93
1983	57.74	34.90	28.87	38.44	35.99
1984	58.98	34.64	29.74	37.89	35.44
1985	60.09	35.96	30.57	38.41	35.02
1986	59.30	37.00	30.91	37.63	34.15
1987	60.00	37.40	31.67	38.96	34.15
1988	63.47	39.16	32.18	40.25	34.14
1989	65.73	39.73	32.02	42.37	34.20
β	0.02	0.02	0.01	0.01	0.02
t value	5.60	9.11	5.18	2.29	5.36

Table 1g

hirf with production

	Bel	Fra	Ger	Ita	UK
1976	3.59	2.97	3.37	3.10	2.98
1977	3.41	2.90	3.27	2.95	2.86
1978	3.58	2.87	3.20	3.00	2.76
1979	3.83	2.94	3.48	3.08	2.73
1980	3.84	2.85	3.19	2.96	2.77
1981	3.92	2.96	3.28	3.02	2.83
1982	3.75	2.97	3.27	2.96	2.86
1983	3.83	3.02	3.31	2.75	2.91
1984	4.01	3.18	3.46	2.88	2.96
1985	4.00	3.16	3.49	2.79	3.00
1986	3.51	3.09	3.30	2.62	2.91
1987	3.36	3.14	3.24	2.64	2.95
1988	3.43	3.18	3.30	2.66	2.98
1989	3.74	3.18	3.35	2.68	3.03
β	0.00	0.01	0.00	-0.01	0.01
t value	-0.16	6.05	0.47	-6.99	2.74

Table 1h

hirf with employment

	Bel	Fra	Ger	Ita	UK
1976	3.26	2.76	3.05	2.87	2.72
1977	3.21	2.75	3.00	2.86	2.71
1978	3.13	2.74	2.98	2.89	2.67
1979	3.14	2.75	2.99	2.89	2.75
1980	3.04	2.71	2.95	2.86	2.83
1981	3.05	2.67	2.96	2.84	2.79
1982	3.03	2.67	2.98	2.77	2.89
1983	3.02	2.71	2.92	2.82	2.92
1984	2.97	2.73	2.98	2.77	2.95
1985	2.95	2.74	3.01	2.75	3.01
1986	2.84	2.76	3.08	2.74	3.00
1987	2.79	2.80	3.07	2.81	2.99
1988	2.77	2.82	3.11	2.80	3.03
1989	2.76	2.82	3.16	2.83	3.07
β	-0.010	0.002	0.003	-0.003	0.010
t value	-17.37	1.93	2.67	-3.18	12.65

Table 1i

fk with production

	Bel	Fra	Ger	Ita	UK
1976	79.22	81.17	80.86	81.79	82.82
1977	79.36	81.46	81.55	81.83	82.60
1978	78.58	80.88	80.66	81.33	82.03
1979	77.69	80.30	80.36	79.66	80.54
1980	76.42	79.23	80.55	78.76	79.13
1981	76.67	79.25	79.89	78.61	78.85
1982	74.92	79.08	79.64	78.46	78.00
1983	74.49	79.27	79.51	77.48	78.37
1984	74.86	79.02	79.52	78.22	78.47
1985	74.83	78.42	79.00	78.04	78.30
1986	74.81	77.76	78.01	77.88	78.29
1987	74.28	77.61	78.10	77.38	78.84
1988	73.40	77.50	77.57	77.29	78.45
1989	73.22	76.68	77.80	76.71	77.73
β	0.006	0.004	0.003	0.005	0.004
t value	11.01	14.58	13.23	8.14	5.30

Table 1j

fk with employment

	Bel	Fra	Ger	Ita	UK
1976	77.53	81.04	78.95	79.51	80.29
1977	77.47	80.71	79.39	79.66	80.16
1978	77.51	80.78	79.37	79.94	80.28
1979	76.98	80.25	79.06	78.85	79.05
1980	76.21	79.07	78.59	78.50	77.99
1981	76.11	78.90	77.81	78.04	77.21
1982	74.20	78.60	76.96	78.16	76.12
1983	75.04	78.40	77.21	77.54	76.13
1984	75.47	78.84	76.93	78.31	76.84
1985	75.07	78.41	76.23	78.26	76.81
1986	75.28	78.19	75.78	78.46	77.38
1987	75.08	77.84	75.43	77.71	77.42
1988	74.19	77.16	74.90	76.89	77.02
1989	73.97	76.95	74.93	76.20	76.58
β	0.003	0.004	0.005	0.003	0.003
t value	6.86	12.20	16.02	6.05	4.19

Table 2a

Sj index with production

	Bel	Den	Fra	Ger	Gre	Ire	Ita	Net	Por	Spa	UK
1968	1.65	2.94	0.98	1.12	2.90	4.65	0.94	2.54	3.50	1.67	0.92
1969	1.72	2.73	1.02	1.25	2.82	4.66	0.93	2.66	3.45	1.69	0.84
1970	1.76	3.14	0.93	1.22	2.85	4.76	0.94	2.79	3.48	1.90	0.78
1971	1.75	2.97	0.95	1.28	2.82	4.56	0.83	2.68	3.39	2.01	0.72
1972	1.76	2.96	0.93	1.24	2.82	5.06	0.90	2.65	3.13	2.06	0.69
1973	1.69	3.40	0.82	1.24	2.73	5.15	0.90	2.88	3.28	1.98	0.69
1974	1.66	3.20	0.76	1.20	2.85	5.24	0.90	2.42	3.18	1.93	0.73
1975	1.71	3.06	0.80	1.23	2.92	5.59	0.86	2.61	3.23	1.93	0.66
1976	1.70	3.11	0.82	1.23	2.92	5.26	0.92	2.64	3.10	1.94	0.55
1977	1.70	3.95	0.81	1.16	3.07	5.61	0.99	2.78	2.85	1.96	0.53
1978	1.80	4.05	0.74	1.17	3.05	5.37	0.98	2.88	2.72	1.29	0.60
1979	1.71	3.82	0.71	1.15	3.04	5.34	1.13	2.80	2.79	1.29	0.58
1980	1.87	3.82	0.61	1.07	3.10	4.95	1.27	2.72	2.72	1.25	0.56
1981	1.84	3.92	0.66	1.13	3.18	4.60	1.09	2.84	2.79	1.28	0.56
1982	1.85	4.07	0.58	1.14	3.32	4.67	1.19	2.80	2.64	1.29	0.55
1983	1.82	4.13	0.69	1.21	3.37	4.39	1.13	2.86	2.88	1.48	0.43
1984	1.84	4.04	0.70	1.25	3.36	4.24	1.16	2.78	2.85	1.51	0.40
1985	1.89	3.84	0.72	1.34	3.54	4.41	1.33	2.79	3.02	1.53	0.49
1986	2.11	3.78	0.70	1.37	3.48	4.64	1.31	2.64	3.13	1.50	0.55
1987	2.10	3.68	0.68	1.42	3.66	4.73	1.33	2.79	3.09	1.55	0.50
1988	2.11	3.68	0.68	1.29	3.56	4.54	1.28	2.78	3.09	1.66	0.55
1989	2.15	3.82	0.67	1.27	3.48	4.40	1.35	2.71	3.14	1.55	0.57
1990	2.18	3.73	0.64	1.26	3.58	4.43	1.29	2.54	3.16	1.55	0.54
β	0.01	0.01	-0.02	0.00	0.01	-0.01	0.02	0.00	-0.01	-0.01	-0.02
t value	8.14	5.45	-7.22	1.94	13.95	-2.34	9.52	1.05	-2.49	-2.86	-6.07

Table 2b

Sj with employment

	Bel	Den	Fra	Ger	Gre	Ire	Ita	Net	Por	Spa	UK
1968	1.46	1.79	0.52	1.31	3.30	3.90	1.28	1.56	4.99	2.06	0.65
1969	1.44	1.76	0.54	1.32	3.25	3.85	1.27	1.69	4.84	2.05	0.63
1970	1.41	1.88	0.58	1.34	3.14	3.89	1.30	1.74	4.98	2.09	0.60
1971	1.40	1.99	0.56	1.30	3.09	3.86	1.08	1.75	4.44	2.10	0.57
1972	1.41	1.98	0.55	1.32	3.01	3.70	1.01	1.74	4.09	2.00	0.58
1973	1.63	1.96	0.56	1.34	3.02	3.65	0.99	1.73	4.07	2.00	0.59
1974	1.59	1.99	0.54	1.40	3.17	3.70	0.98	1.69	4.05	2.02	0.57
1975	1.53	2.02	0.53	1.43	3.30	3.84	0.98	1.72	3.90	2.01	0.59
1976	1.49	2.01	0.56	1.41	3.29	3.65	0.96	1.76	3.65	1.95	0.58
1977	1.47	2.26	0.55	1.30	3.27	3.52	1.00	1.90	3.65	1.91	0.54
1978	1.44	2.30	0.52	1.28	3.30	3.50	0.98	1.95	3.70	1.55	0.53
1979	1.34	2.36	0.52	1.29	3.32	3.40	0.99	2.01	3.68	1.57	0.52
1980	1.40	2.36	0.52	1.23	3.40	3.27	1.01	2.05	3.72	1.49	0.56
1981	1.44	2.39	0.50	1.27	3.39	3.18	1.05	2.04	3.76	1.47	0.59
1982	1.50	2.32	0.49	1.31	3.48	3.13	1.05	2.06	3.71	1.41	0.55
1983	1.52	2.37	0.54	1.36	3.50	3.13	1.11	2.06	3.76	1.43	0.54
1984	1.55	2.33	0.61	1.37	3.49	3.13	1.12	2.06	3.86	1.49	0.57
1985	1.60	2.28	0.64	1.41	3.58	3.10	1.12	2.05	3.99	1.60	0.56
1986	1.59	2.34	0.65	1.48	3.67	3.08	1.15	2.03	4.11	1.67	0.56
1987	1.51	2.39	0.65	1.53	3.71	3.01	1.18	2.04	4.20	1.67	0.58
1988	1.50	2.39	0.65	1.54	3.65	2.90	1.22	2.02	4.16	1.73	0.57
1989	1.52	2.34	0.65	1.54	3.72	2.76	1.25	1.96	4.21	1.73	0.59
1990	1.58	2.27	0.67	1.54	3.70	2.72	1.29	1.92	4.24	1.74	0.61
β	0.00	0.01	0.01	0.01	0.00	-0.02	0.00	0.01	-0.01	-0.01	0.00
t value	2.05	8.00	3.64	3.73	9.71	-19.99	0.97	6.92	-1.95	-4.29	-1.52

Table 2c

gini with production

	Bel	Den	Fra	Ger	Gre	Ire	Ita	Net	Por	Spa	UK
1968	20.59	27.47	11.48	11.91	35.18	43.85	13.89	22.94	38.96	21.26	11.35
1969	21.05	26.47	11.35	12.84	33.96	44.23	14.01	24.24	39.02	21.47	10.69
1970	21.59	29.66	11.04	12.68	34.38	45.67	14.01	25.67	39.10	23.14	10.01
1971	21.65	28.00	11.31	12.71	33.68	43.84	12.67	24.76	38.74	24.22	9.58
1972	21.62	28.59	11.40	12.74	33.10	44.59	13.38	24.15	35.74	24.64	9.63
1973	21.25	30.77	10.19	12.82	32.34	45.16	12.60	25.84	37.09	23.70	9.51
1974	21.24	30.93	9.68	13.23	33.15	45.18	12.44	24.22	36.12	22.16	9.49
1975	21.50	29.63	9.85	13.52	34.91	45.69	12.32	25.26	36.27	22.57	8.54
1976	21.50	30.03	10.01	13.35	35.14	44.22	12.89	25.84	35.92	23.01	8.16
1977	21.81	33.07	10.09	12.70	36.87	44.46	13.78	27.59	34.44	23.17	8.03
1978	22.02	33.22	9.63	12.51	37.44	43.04	13.26	27.81	32.65	16.37	8.31
1979	21.29	33.04	9.07	12.48	37.42	42.71	15.03	28.09	33.90	16.46	8.06
1980	22.11	33.21	8.19	11.68	37.55	40.77	17.15	27.60	33.29	15.68	7.47
1981	22.13	31.89	8.78	12.23	37.54	40.70	15.08	29.09	34.33	16.08	7.27
1982	22.17	32.71	7.81	12.06	39.05	40.93	15.56	28.32	32.96	15.72	7.51
1983	21.97	33.31	8.90	13.02	40.00	39.74	15.50	29.43	35.10	17.41	6.34
1984	22.49	33.76	9.04	13.44	40.61	40.08	15.72	29.02	35.73	17.93	5.82
1985	22.13	33.88	9.18	14.54	41.56	41.31	17.21	29.20	37.69	18.05	6.90
1986	23.21	34.31	9.35	14.27	42.04	41.41	16.53	27.38	39.16	17.61	7.59
1987	23.30	33.95	9.24	14.97	43.41	41.80	17.01	29.37	38.58	17.88	7.10
1988	23.27	33.69	9.01	13.81	43.32	41.47	17.03	29.54	38.32	18.92	7.79
1989	23.60	34.35	8.81	13.64	41.82	41.32	18.38	29.75	39.11	17.70	8.32
1990	23.83	33.07	8.49	13.42	43.62	40.59	17.23	27.85	38.62	18.05	7.48
β	0.01	0.01	-0.01	0.01	0.01	-0.01	0.01	0.01	0.00	-0.01	-0.02
t value	9.92	8.47	-6.36	2.93	12.74	-6.23	7.01	8.39	0.01	-4.35	-6.04

Table 2d

gini with employment

	Bel	Den	Fra	Ger	Gre	Ire	Ita	Net	Por	Spa	UK
1968	19.57	24.00	7.57	14.28	40.04	41.87	15.58	19.88	47.49	25.15	8.87
1969	19.73	23.94	7.62	14.26	39.19	41.56	15.71	21.64	47.33	25.06	8.66
1970	19.41	25.18	7.74	14.48	38.50	41.85	16.05	22.08	48.12	25.57	8.31
1971	19.40	25.47	7.44	14.16	37.31	41.37	13.75	22.20	46.59	25.43	8.29
1972	19.80	25.31	7.49	14.31	35.90	39.42	13.04	21.86	42.98	24.59	8.26
1973	21.33	25.15	7.60	14.60	35.43	37.97	12.89	21.71	41.88	24.57	8.25
1974	21.22	25.18	7.44	15.35	36.61	38.18	12.85	21.23	42.01	24.68	8.23
1975	20.05	25.20	7.34	15.77	37.78	39.48	12.85	21.86	41.29	24.82	8.37
1976	19.98	25.07	7.40	15.65	37.76	37.68	12.69	22.51	38.81	24.28	8.30
1977	19.66	26.62	7.41	14.80	37.87	36.42	13.27	23.76	39.17	23.75	7.88
1978	19.55	27.05	7.12	14.63	38.14	36.63	13.15	24.40	39.25	19.99	7.89
1979	18.46	27.69	7.22	14.76	38.36	35.56	13.34	25.09	38.82	20.09	7.82
1980	18.64	27.52	7.24	14.31	39.40	34.57	13.58	25.33	38.85	19.25	7.74
1981	18.95	27.17	7.05	14.58	39.56	34.16	14.07	25.62	39.04	18.74	8.06
1982	19.63	26.51	7.04	15.08	40.33	33.63	14.11	25.77	38.74	17.71	7.67
1983	19.85	27.13	7.32	15.47	40.31	33.72	15.53	25.53	39.19	17.51	7.59
1984	20.24	27.05	8.22	15.58	40.37	33.54	15.53	25.67	40.11	18.12	8.16
1985	20.36	26.74	8.57	15.88	40.98	33.94	15.61	25.60	41.76	19.10	7.95
1986	20.17	27.41	8.76	16.43	41.90	34.08	15.95	25.30	42.81	19.82	7.75
1987	19.24	28.03	8.81	16.90	42.04	33.44	16.20	25.41	43.74	19.82	7.83
1988	19.28	28.03	9.04	17.00	41.89	32.14	16.53	24.81	42.91	20.22	7.95
1989	19.41	27.56	9.17	17.02	42.81	31.23	16.96	24.22	43.43	19.98	8.04
1990	19.63	26.84	9.35	17.06	42.89	31.40	17.57	23.90	43.92	20.21	8.14
β	0.00	0.01	0.01	0.01	0.01	-0.01	0.01	0.01	0.00	-0.02	0.00
t value	-0.79	7.74	4.04	6.81	5.84	-19.36	2.92	6.30	-1.73	-6.29	-4.17

Table 2e

σj with production

	Bel	Den	Fra	Ger	Gre	Ire	Ita	Net	Por	Spa	UK
1968	37.95	40.32	27.27	38.72	51.78	66.48	37.68	33.93	60.29	38.45	37.26
1969	37.90	39.39	26.17	41.76	47.35	69.04	36.10	35.17	59.56	39.38	35.93
1970	36.34	43.95	27.56	42.71	46.77	70.35	37.44	38.19	59.39	41.34	35.17
1971	35.94	42.07	27.74	42.56	47.09	65.91	34.80	36.54	55.03	44.28	33.10
1972	35.57	42.64	27.44	41.41	48.54	68.32	36.01	36.71	52.45	47.83	31.06
1973	35.10	46.50	25.52	42.47	48.15	68.72	34.97	40.16	58.05	45.74	30.43
1974	36.56	47.25	23.22	41.84	49.08	70.72	36.07	38.66	58.03	44.34	29.58
1975	35.61	44.27	25.03	42.74	53.88	72.77	36.09	38.39	52.81	44.89	30.33
1976	35.55	44.03	26.48	42.41	54.69	70.28	35.69	41.13	51.73	45.27	29.57
1977	37.07	50.40	27.41	42.73	59.54	70.01	38.11	41.80	50.98	46.87	29.82
1978	35.95	49.73	27.03	43.09	59.38	65.81	39.58	41.11	48.75	25.47	31.22
1979	35.91	49.27	25.61	42.63	59.23	66.05	40.55	43.30	54.73	24.77	29.90
1980	33.91	50.02	24.87	40.92	59.24	62.52	43.15	42.26	54.87	22.34	29.33
1981	33.86	50.01	25.49	41.37	57.85	60.98	40.69	45.13	54.16	23.77	29.40
1982	33.54	51.52	24.51	41.00	62.17	62.17	42.05	43.07	50.05	24.05	28.34
1983	33.32	52.89	25.36	42.17	62.85	61.17	40.94	44.65	53.58	26.27	27.05
1984	34.79	52.29	26.03	42.43	65.48	61.66	40.37	43.99	52.37	26.78	25.27
1985	33.69	51.93	25.78	45.27	65.52	63.97	42.36	44.08	58.74	26.79	28.30
1986	34.51	50.57	27.19	45.78	66.71	63.13	41.70	41.19	61.81	26.81	29.23
1987	34.17	48.39	27.99	47.51	68.93	64.33	41.37	44.69	61.55	29.74	28.88
1988	34.53	48.12	27.18	44.73	68.93	63.59	42.37	44.62	58.97	30.64	28.96
1989	34.88	49.59	26.63	44.24	63.80	62.46	46.33	45.07	58.96	29.08	29.67
1990	35.20	48.03	27.98	44.42	67.63	60.70	44.01	41.68	57.78	29.30	29.49
β	0.00	0.01	0.00	0.00	0.02	-0.01	0.01	0.01	0.00	-0.03	-0.01
t value	-4.64	5.42	0.36	4.06	12.61	-5.08	8.17	7.47	0.52	-4.26	-5.03

Table 2f

σj with employment

	Bel	Den	Fra	Ger	Gre	Ire	Ita	Net	Por	Spa	UK
1968	34.92	37.05	28.03	48.22	56.19	58.44	32.48	32.50	76.39	33.89	35.11
1969	36.05	37.76	28.11	48.46	53.01	57.67	32.54	31.78	74.38	33.24	34.73
1970	36.10	38.67	28.50	49.23	52.45	58.29	32.97	33.36	77.68	34.21	34.01
1971	36.73	38.68	28.67	48.33	48.95	56.89	32.52	33.19	73.55	35.15	32.85
1972	36.85	37.91	28.08	46.87	46.26	54.91	32.04	33.06	68.52	35.52	30.51
1973	35.64	38.20	28.57	47.17	45.65	54.62	32.84	33.25	67.73	36.36	29.92
1974	36.10	39.48	28.30	48.25	48.09	55.57	32.45	33.45	68.74	36.99	29.42
1975	34.39	39.04	28.32	48.69	49.38	58.87	33.01	34.99	66.14	37.80	29.39
1976	34.11	37.84	28.45	47.85	49.77	55.23	32.84	36.52	62.03	37.31	28.51
1977	34.28	40.11	28.33	45.81	51.17	52.40	33.81	39.77	62.50	36.61	28.32
1978	34.04	40.61	27.41	45.42	51.63	52.07	34.32	40.97	63.24	25.41	28.20
1979	32.20	41.99	26.56	45.32	52.31	49.66	34.70	42.43	64.47	25.32	27.65
1980	32.02	42.26	25.79	44.53	54.45	48.12	34.50	42.86	65.66	25.08	27.57
1981	32.05	41.91	25.51	44.87	55.31	47.33	34.87	43.84	67.29	24.84	26.68
1982	32.80	40.67	25.24	45.69	56.99	47.13	34.77	44.57	67.24	23.04	25.12
1983	33.15	41.67	26.10	45.85	57.91	49.19	37.18	44.72	69.15	23.57	24.32
1984	33.66	41.88	27.39	46.09	58.19	49.40	36.25	45.08	72.20	24.74	24.13
1985	33.10	42.08	27.86	47.32	58.65	49.20	36.42	45.32	74.12	25.23	24.15
1986	33.35	43.18	27.79	48.96	60.62	49.52	37.25	45.21	77.19	26.13	23.00
1987	31.35	43.90	27.51	49.78	61.26	48.36	37.31	46.01	79.72	26.46	22.19
1988	31.45	44.57	27.61	49.90	62.22	46.14	37.83	44.29	79.82	25.81	22.16
1989	31.94	44.36	27.65	49.92	64.58	44.82	38.44	43.56	81.89	26.25	22.39
1990	32.41	43.69	28.01	50.21	65.25	44.95	38.85	43.51	82.98	26.10	23.39
β	-0.01	0.01	0.00	0.00	0.01	-0.01	0.01	0.02	0.01	-0.02	-0.02
t value	-7.41	13.38	-1.88	0.62	6.43	-11.12	15.30	10.64	1.84	-5.36	-22.80

Table 2g

hirf index with production

	Bel	Den	Fra	Ger	Gre	Ire	Ita	Net	Por	Spa	UK
1968	7.58	10.66	7.50	6.19	8.49	15.06	6.43	10.23	10.45	6.97	6.50
1969	7.67	9.86	7.40	6.42	8.08	14.49	6.29	10.16	9.89	6.88	6.54
1970	7.62	10.61	7.31	6.63	7.82	14.34	6.32	10.30	9.44	6.94	6.59
1971	7.51	10.49	7.35	6.55	7.93	13.88	6.46	10.19	9.83	6.76	6.63
1972	7.56	10.49	7.31	6.51	7.93	16.13	6.43	10.28	9.36	6.80	6.60
1973	7.61	11.72	7.13	6.53	7.63	16.34	6.27	10.74	9.24	6.92	6.39
1974	7.56	10.52	6.88	6.58	7.93	16.03	6.33	9.57	8.77	7.08	6.33
1975	7.60	10.90	7.27	6.70	7.83	18.24	6.51	10.27	9.54	6.94	6.50
1976	7.63	10.82	7.26	6.71	7.80	16.76	6.40	10.20	9.12	7.04	6.45
1977	7.54	13.69	7.40	6.84	7.94	18.71	6.37	10.65	8.45	7.02	6.60
1978	7.91	14.18	7.36	6.85	7.78	18.18	6.48	11.03	8.30	6.87	6.55
1979	7.82	13.02	7.20	6.74	7.93	17.73	6.24	10.77	8.01	6.82	6.54
1980	8.11	12.87	7.19	6.73	8.21	16.08	6.19	10.56	7.93	6.75	6.65
1981	8.17	13.60	7.43	6.88	8.89	14.91	6.12	11.15	8.44	6.87	6.77
1982	8.22	14.21	7.45	7.09	8.86	15.43	6.18	11.12	8.20	7.15	6.83
1983	8.05	14.45	7.43	7.14	8.78	14.88	6.16	11.17	8.60	7.26	6.79
1984	7.95	13.97	7.40	7.15	8.61	14.46	6.25	11.11	8.75	7.29	6.90
1985	8.13	13.03	7.32	7.39	8.97	14.80	5.79	10.88	8.50	7.25	6.88
1986	8.72	12.97	7.28	7.58	8.27	15.84	5.90	10.44	8.29	7.21	6.96
1987	8.43	12.28	7.23	7.80	8.39	15.97	5.83	10.40	7.95	7.54	6.86
1988	8.32	12.21	7.20	7.66	7.82	15.36	6.35	10.02	8.03	7.62	6.87
1989	8.23	12.47	7.26	7.74	7.94	14.71	6.43	9.66	7.94	7.60	6.91
1990	8.34	12.44	7.29	7.75	8.01	14.72	6.39	9.43	8.14	7.40	6.97
β	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	-0.01	0.00	0.00
t value	8.39	4.14	-0.19	15.06	1.61	-0.46	-2.34	0.05	-7.28	5.82	7.04

Table 2h

hirf with employment

	Bel	Den	Fra	Ger	Gre	Ire	Ita	Net	Por	Spa	UK
1968	6.41	6.82	6.38	7.11	7.94	9.61	6.07	7.08	12.99	6.42	6.91
1969	6.45	6.85	6.42	7.25	7.83	9.41	6.10	6.95	12.14	6.40	6.93
1970	6.52	6.91	6.49	7.42	7.53	9.35	6.11	7.03	12.35	6.28	6.92
1971	6.55	7.01	6.55	7.45	7.61	9.17	6.15	7.06	10.51	6.16	6.89
1972	6.54	6.98	6.54	7.38	7.61	8.87	6.18	7.04	9.59	6.06	6.83
1973	6.40	7.05	6.59	7.45	7.71	8.84	6.20	7.04	9.54	6.09	6.93
1974	6.35	7.26	6.61	7.63	7.74	8.87	6.21	7.05	9.36	6.05	6.93
1975	6.35	7.28	6.66	7.67	7.91	9.10	6.25	7.17	9.01	6.05	6.94
1976	6.35	7.15	6.70	7.65	8.03	8.77	6.24	7.20	8.62	6.08	6.92
1977	6.30	7.57	6.71	7.65	7.87	8.55	6.26	7.53	8.50	6.03	6.95
1978	6.26	7.64	6.73	7.67	7.90	8.48	6.31	7.58	8.62	6.05	6.96
1979	6.31	7.73	6.74	7.71	7.89	8.38	6.40	7.65	8.53	6.07	6.96
1980	6.35	7.90	6.75	7.71	7.90	8.15	6.43	7.69	8.51	6.03	7.12
1981	6.35	8.12	6.80	7.82	7.93	8.05	6.42	7.77	8.56	6.02	7.16
1982	6.36	8.13	6.88	7.94	7.89	8.07	6.45	7.82	8.44	6.15	7.11
1983	6.40	8.19	6.94	8.16	7.89	8.18	6.45	7.84	8.48	6.20	7.09
1984	6.41	8.16	6.98	8.18	7.89	8.39	6.42	7.89	8.52	6.20	7.02
1985	6.47	8.27	7.00	8.38	8.03	8.34	6.47	7.84	8.61	6.30	7.02
1986	6.52	8.28	6.95	8.60	8.14	8.28	6.63	7.82	8.83	6.27	6.95
1987	6.48	8.27	6.92	8.70	8.24	8.25	6.59	8.06	8.93	6.31	6.91
1988	6.48	8.33	6.90	8.72	8.15	8.27	6.64	7.91	8.92	6.39	6.84
1989	6.50	8.34	6.88	8.79	8.20	8.07	6.65	7.84	8.89	6.40	6.81
1990	6.52	8.36	6.92	8.88	8.07	7.97	6.69	7.89	8.87	6.41	6.92
β	0.00	0.01	0.00	0.01	0.00	-0.01	0.00	0.01	-0.01	0.00	0.00
t value	0.70	18.35	13.24	17.45	5.72	-9.53	25.65	12.34	-4.54	1.38	0.66

Table 2i

f-k index with production

	Bel	Den	Fra	Ger	Gre	Ire	Ita	Net	Por	Spa	UK
1968	78.26	76.88	80.75	77.32	74.46	69.93	78.31	78.47	71.38	77.94	77.88
1969	78.28	76.99	80.96	76.41	75.08	69.51	78.72	77.98	71.44	77.54	78.22
1970	78.25	75.63	80.40	75.91	75.34	68.67	77.95	76.92	71.57	76.74	78.11
1971	78.00	76.51	80.38	76.23	75.71	70.13	78.56	77.70	72.52	76.61	78.95
1972	77.66	75.89	80.45	76.59	75.25	68.89	78.35	77.20	73.70	75.85	79.47
1973	77.30	74.60	80.65	76.17	74.82	67.89	78.35	75.74	72.39	75.73	79.32
1974	77.03	74.54	80.83	76.32	74.89	67.53	78.30	75.70	73.33	76.15	79.50
1975	76.97	75.29	80.49	75.63	73.29	66.60	78.03	75.69	73.39	75.76	79.28
1976	77.05	75.37	80.13	75.56	73.36	67.21	77.83	75.08	73.64	75.79	79.28
1977	76.51	73.32	79.90	75.39	72.55	67.26	77.25	74.26	73.76	75.22	79.19
1978	77.41	73.96	80.70	75.92	72.12	68.68	77.74	74.84	75.04	80.52	79.21
1979	77.39	73.85	80.78	76.04	71.82	68.96	77.06	74.16	73.88	80.28	79.31
1980	77.57	73.90	81.20	76.79	71.61	70.25	76.50	74.69	74.23	81.04	79.96
1981	77.80	74.47	81.02	76.28	72.27	69.87	77.26	73.78	73.94	80.79	79.70
1982	77.60	73.73	81.26	76.30	70.99	69.46	76.92	74.32	74.46	80.55	79.96
1983	77.16	73.23	80.35	75.44	70.51	69.43	76.72	73.30	73.13	79.45	79.97
1984	76.96	72.67	79.83	74.99	69.34	68.44	76.33	73.61	72.53	79.24	79.80
1985	76.49	72.14	79.30	73.97	68.84	67.32	75.46	73.51	71.24	78.62	78.87
1986	76.34	72.72	79.34	74.05	69.22	67.95	75.59	74.82	70.62	78.81	78.85
1987	76.21	73.09	79.07	73.45	68.44	67.77	75.36	73.89	71.06	78.14	78.77
1988	76.04	73.38	79.03	74.22	67.92	67.81	74.80	73.94	70.61	77.93	78.55
1989	76.17	73.12	78.89	74.23	69.14	67.89	74.04	73.98	70.27	78.26	78.32
1990	76.29	73.89	79.11	74.57	67.71	69.10	75.06	74.88	70.66	78.14	78.88
β	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
t value	6.46	7.59	4.34	6.06	17.62	0.96	12.93	6.90	1.63	-2.40	-0.81

Table 2j

fk with employment

	Bel	Den	Fra	Ger	Gre	Ire	Ita	Net	Por	Spa	UK
1968	77.44	77.73	80.02	74.71	72.43	71.14	78.48	78.49	66.57	78.07	77.98
1969	77.26	77.73	80.04	74.58	73.02	71.40	78.51	78.74	66.96	78.33	78.08
1970	77.07	77.33	79.69	74.21	73.66	71.31	78.22	78.28	66.67	78.01	78.19
1971	77.21	77.57	79.88	74.97	74.76	71.95	78.79	78.45	68.17	78.28	78.74
1972	77.37	78.05	80.43	75.68	75.37	73.19	79.32	79.08	70.27	78.75	79.58
1973	77.75	77.96	80.49	75.50	75.71	73.76	79.16	79.16	70.94	78.94	79.71
1974	77.53	77.35	80.34	74.83	74.43	73.49	79.03	78.73	70.75	78.39	79.66
1975	77.93	77.35	80.18	74.63	73.38	72.61	78.79	78.01	71.18	77.96	79.53
1976	78.44	78.04	80.29	75.07	73.75	73.71	79.24	77.92	72.57	78.51	79.86
1977	78.42	77.32	80.28	75.63	73.38	74.24	78.98	77.01	72.09	78.44	79.86
1978	78.59	77.31	80.65	75.85	73.41	73.78	79.01	76.89	71.99	80.60	80.11
1979	79.14	76.89	80.89	75.88	73.26	74.67	78.81	76.58	71.87	80.68	80.34
1980	79.03	76.92	81.21	76.27	72.60	75.31	78.85	76.51	71.81	80.90	80.39
1981	78.99	77.00	81.33	76.10	72.42	75.32	78.73	76.31	71.41	80.90	80.62
1982	78.83	77.25	81.47	75.73	71.79	75.56	78.71	76.20	71.45	81.14	81.16
1983	78.56	76.70	81.11	75.18	71.42	74.88	78.12	76.07	70.73	80.85	81.05
1984	78.27	76.38	80.42	74.73	71.20	74.43	77.93	75.64	69.70	80.24	80.95
1985	78.11	76.08	80.06	74.14	70.84	74.10	77.70	75.66	68.90	79.90	80.69
1986	77.95	75.48	79.90	73.39	70.21	73.90	77.19	75.62	68.13	79.45	80.71
1987	78.37	75.21	79.91	73.01	69.77	74.16	76.88	75.10	67.47	79.28	80.71
1988	78.66	75.25	79.96	72.95	69.77	74.84	76.98	75.85	68.07	79.68	80.87
1989	78.57	75.45	80.03	73.02	69.14	75.22	76.80	76.09	67.66	79.58	80.95
1990	78.53	75.88	80.04	72.94	69.28	75.03	76.62	76.21	67.57	79.60	80.90
β	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
t value	-4.29	8.78	-0.41	2.73	7.78	-6.20	5.47	9.87	0.20	-3.50	-9.70

Table 3a: Sjt index with production (EUROSTAT)

industry	t=1976	t=1989
4940 toys & sports goods	4.62	2.31
4950 miscellaneous industries	3.64	3.90
4190 bread & flour confectionary	3.63	2.45
2550 manuf of paint	3.53	3.10
4650 other wood manufactures	3.48	3.76
4310 wool industry	3.42	4.12
3270 other machinery: specific industry	2.99	3.93
4380 carpets & other floor coverings	2.89	3.60
4140 processing of fruit & vegetables	2.85	1.69
4270 brewing & malting	2.84	3.39
3620 railway & tramway rolling stock	2.77	3.47
4510 mass-produced footwear	2.72	4.53
4120 slaughtering & preparing meat	2.67	2.94
4220 aminal & poultry foods	2.64	2.29
4910 jewellery	2.59	4.07
3710 measuring instruments	2.51	3.04
4230 other food products	2.47	1.79
4240 spirit distilling & compounding	2.42	2.36
4610 sawing & processing of wood	2.34	1.88
4130 manuf of dairy products	2.31	2.53
4620 semi-finished wood products	2.19	1.51
3150 boilermaking	2.18	2.78
4660 plaiting materials	2.15	1.16
3280 manuf of other machinery	2.11	1.55
3230 manuf of textile machinery	2.10	3.56
2410 manuf of clay products	2.08	2.18
3260 manuf of transmission equipment	2.04	2.17
4670 wooden furniture	2.03	0.98
4150 processing of fish & seafoods	1.97	3.68
3130 secondary transform of metals	1.97	2.44
3220 manuf of tools	1.96	3.11
2480 manuf of ceramic goods	1.96	2.77
2450 working of stone	1.83	4.84
4160 grain milling	1.79	2.73
3140 manuf of structural metals	1.77	1.17
2420 cement, lime & plaster	1.67	1.56
4630 carpentry & joinery components	1.63	0.86
2430 manuf of concrete for construction	1.46	0.42
4730 printing & allied industries	1.38	3.06
3240 manuf food & chemical machinery	1.34	2.08
2570 manuf of pharmaceutical products	1.32	1.62
4720 processing of paper & board	1.27	1.30
2230 drawing & cold rolling	1.22	0.86
4360 knitting industry	1.16	3.00
2470 manuf of glass & glassware	1.11	0.95
3250 manuf of plant for mines	1.07	1.09
4320 cotton industry	1.06	1.86

Table 3a continued	t=1976	t=1989
4390 miscellaneous textile industries	1.05	1.17
4810 rubber products	1.05	0.87
3160 manuf of tools	1.02	2.17
2510 manuf of basic industrial chemicals	0.99	1.42
3110 foundaries	0.87	0.84
3610 shipbuilding	0.83	1.58
4280 manuf of soft drinks	0.81	1.49
2580 manuf of soap & toilet preparations	0.81	1.40
4370 textile finishing	0.80	3.45
4710 pulp, paper & baord	0.76	0.59
2240 processing of non-ferrous metals	0.73	0.67
3210 manuf of agricultural machinery	0.68	1.89
4530 ready made clothing	0.63	2.24
4110 vegetable & animal oils	0.60	1.27
4210 cocoa, chocolate & sugar confection	0.59	1.85
4560 furs & fur goods	0.56	3.58
2210 iron & steel	0.52	0.88
4830 processing of plastics	0.48	0.50

Table 3b: Sjt index with production (UNIDO)

industry	t=1968	t=1990
354 misc. petroleum & coal products	5.63	4.17
361 poettery, china, earthenware	3.61	6.60
314 tobacco	3.36	3.70
390 other manufactured products	3.12	3.56
353 petroleum refineries	3.12	1.16
385 professional & scientific equip	2.65	2.22
311 food products	2.35	2.33
342 printing & publishing	2.12	3.38
313 beverages	2.02	1.52
372 non-ferrous metals	1.96	0.94
331 wood products	1.95	1.20
352 other chemicals	1.90	1.49
356 plastic products	1.88	0.62
332 furniture	1.85	1.43
383 machinery electric	1.77	1.63
351 industrial chemicals	1.69	1.58
355 rubber products	1.61	0.93
384 transport equipment	1.43	1.56
362 glass & products	1.42	0.95
382 machinery, except electrical	1.39	1.68
324 footwear	1.39	5.87
371 iron & steel	1.32	1.53
323 leather products	1.32	5.37
321 textiles	1.08	3.09
322 wearing apparel	1.03	3.07
369 other non-metallic mineral prod	1.01	1.92
341 paper & products	0.68	0.89
381 fabricated metal products	0.60	1.22

Table 4a

Changes in Si index with NACE production

		β	t value
industries with positive & significant growth			
2450	working of stone	0.09	6.68
2510	manuf basic industrial chemicals	0.02	4.38
2570	manuf of pharmaceutical products	0.02	4.18
2580	manuf soap & toilet preparations	0.05	6.91
3150	boilermaking	0.01	2.74
3160	manuf of tools	0.06	10.28
3210	manuf of agricultural machinery	0.03	2.30
3220	manuf of machine tools	0.04	9.30
3230	manuf of textile machinery	0.04	4.50
3240	manuf food & chemical machinery	0.03	2.99
3270	other machinery:specific industry	0.03	10.07
3610	shipbuilding	0.03	2.18
4110	vegetable & animal oils	0.06	4.78
4120	slaughtering & preparing meats	0.02	4.35
4130	manuf of dairy products	0.02	3.30
4150	processing of fish & sea foods	0.06	2.68
4160	grain milling	0.02	7.24
4210	cocoa, chocolate & sugar	0.12	5.63
4270	brewing & malting	0.01	6.21
4280	manuf of soft drinks	0.03	2.11
4310	wool industry	0.01	4.79
4320	cotton industry	0.03	4.63
4360	knitting industry	0.09	13.74
4370	textile finishing	0.12	8.96
4380	carpets & other floor coverings	0.03	5.85
4510	mass-produced footwear	0.04	9.01
4530	ready made clothing	0.10	10.93
4560	furs & fur goods	0.06	2.73
4730	printing & allied industries	0.05	7.48
4830	processing of plastics	0.03	2.05
4910	jewellery	0.03	4.48
industries with negative significant growth			
2430	manuf concrete for construction	-0.13	-4.37
3280	manuf of other machinery	-0.02	-4.91
4140	processing of fruit & vegetables	-0.04	-2.90
4190	bread & flour confectionary	-0.02	-6.14
4220	animal & poultry foods	-0.01	-2.39
4620	semi-finished wood products	-0.03	-10.00
4630	carpentry & joinery components	-0.09	-3.86
4660	plaiting materials	-0.03	-2.42
4670	wooden furniture	-0.05	-5.15
4710	pulp, paper & board	-0.03	-3.62
4810	rubber products	-0.03	-2.76

Table 4a continued

	β	t value
industries with no significant change		
2210 iron & steel	0.01	0.35
2230 Drawing & cold rolling	0.00	-0.37
2240 processing of non ferrous metal	-0.01	-1.30
2410 manuf of clay products	0.00	-0.24
2420 manuf of cement, lime & plaster	-0.01	-1.07
2470 manuf of glass & glassware	-0.01	-1.23
2480 manuf of ceramic goods	0.01	1.84
2550 manuf of paint	0.00	0.61
3110 foundaries	0.01	1.40
3130 secondary transform of metals	0.01	1.08
3140 manuf of structural metals	-0.02	-1.22
3250 manuf plant for mines	0.03	1.71
3260 manuf of transmission equipment	0.01	1.83
3620 railway & tramway rolling stock	0.00	0.22
3710 meausuring instruments	0.00	0.10
4230 other food products	-0.01	-1.44
4240 spirit distilling & compounding	-0.01	-1.27
4390 miscellaneous textile industries	0.00	0.14
4610 sawing & processing of wood	0.01	0.95
4650 other wood manufactures	0.01	1.40
4720 processing of paper & board	-0.01	-1.16
4940 toys & sports	-0.02	-1.44
4950 miscellaneous	0.01	1.50

Table 4b

Si index with UNIDO production

	β	t value
industries with positive & significant growth		
321 textiles	0.05	16.45
322 wearing apparel	0.07	12.49
323 leather products	0.05	13.65
324 footwear	0.05	10.73
342 printing & publishing	0.02	13.56
361 pottery, china, earthenware	0.04	9.19
369 other non-metalic mineral products	0.03	6.61
371 iron & steel	0.01	2.17
381 fabricated metal products	0.03	2.73
384 transport equipment	0.02	4.16
industries with negative significant growth		
313 beverages	-0.01	-3.42
332 furniture	-0.02	-5.97
352 other chemicals	-0.03	-2.83
353 petroleum refineries	-0.05	-7.11
354 misc. petroleum & coal products	-0.01	-2.28
355 rubber products	-0.01	-3.96
356 plastic products	-0.06	-13.91
362 glass & products	-0.01	-2.14
372 non-ferrous metals	-0.03	-5.57
383 electrical machinery	-0.01	-3.21
industries with no significant change		
311 food products	0.00	-1.48
314 tobacco	0.00	1.66
331 wood products	-0.01	-1.69
341 paper & products	0.00	-0.64
351 industrial chemicals	0.00	0.86
382 machinery	0.00	0.62
385 professional & scientific equip	-0.01	-2.13
390 other manufactured products	0.00	1.91

Table 5a

Dependent variable	Si		ln Si	
	β	t value	β	t value
constant	-2.82	-5.87	-7.00	-8.82
X1	0.19	2.54	0.35	3.16
X2	0.05	2.04	1.16	1.25
X3	0.32	4.29	1.11	3.85
industry dummies:				
Drawing & cold rolling	1.31	2.70	0.83	3.46
processing of non ferrous metal	0.80	1.95	0.35	2.10
manuf of clay products	3.36	6.01	2.29	6.80
manuf of cement, lime & plaster	2.42	5.27	1.54	7.41
manuf concrete for construction	1.48	2.80	0.76	2.41
working of stone	4.64	8.58	2.70	7.76
manuf of glass & glassware	2.12	4.39	1.26	5.62
manuf of ceramic goods	3.48	6.70	2.12	8.15
manuf basic industrial chemicals	1.09	3.74	0.61	5.36
manuf of paint	3.57	7.25	2.09	8.61
manuf of pharmaceutical products	2.06	4.68	1.24	6.58
manuf soap & toilet preparations	1.35	3.09	0.74	4.00
founaries	1.91	3.73	1.15	4.38
secondary transform of metals	3.73	6.61	2.50	7.01
manuf of structural metals	1.93	3.65	1.39	4.46
boilermaking	3.44	6.62	2.17	7.72
manuf of tools	2.39	4.56	1.61	5.66
manuf of agricultural machinery	1.93	4.01	1.27	5.48
manuf of machine tools	3.77	6.96	2.35	7.78
manuf of textile machinery	3.97	7.97	2.23	9.26
manuf food & chemical machinery	2.55	4.89	1.69	6.15
manuf plant for mines	1.78	3.64	1.10	4.59
manuf of transmission equipment	3.12	6.16	1.90	7.81
other machinery:specific industry	4.36	8.38	2.48	9.07
manuf of other machinery	2.52	5.07	1.62	6.65
shipbuilding	1.99	4.78	1.23	7.01
railway & tramway rolling stock	3.60	10.01	1.89	12.69
meausuring instruments	4.18	7.74	2.46	8.63
slaughtering & preparing meats	2.66	5.24	1.80	6.77
processing of fruit & vegetables	2.17	4.42	1.50	6.11
processing of fish & sea foods	3.14	6.46	1.86	7.81
grain milling	2.23	4.26	1.79	5.72
bread & flour confectionary	3.70	7.26	2.20	8.37
cocoa, chocolate & sugar	1.67	3.89	0.93	5.24
animal & poultry foods	2.17	4.21	1.72	5.81
other food products	2.09	4.60	1.40	6.84
brewing & malting	4.33	8.16	2.48	9.13
manuf of soft drinks	1.59	3.18	1.04	3.95
wool industry	4.31	8.57	2.36	8.99
cotton industry	1.97	4.16	1.27	5.76
knitting industry	2.95	5.67	1.90	6.70

Table 5a continued

Dependent variable		Si		ln Si	
		β	t value	β	t value
industry dummies					
textile finishing		3.22	6.02	2.02	6.60
carpets & other floor coverings		3.61	7.68	2.01	9.28
miscellaneous textile industries		2.09	3.91	1.51	4.79
mass-produced footwear		4.45	8.50	2.52	8.61
ready made clothing		2.13	4.05	1.46	4.83
furs & fur goods		3.05	5.62	2.21	5.97
sawing & processing of wood		2.56	4.76	2.01	5.54
semi-finished wood products		2.50	4.91	1.74	6.30
carpentry & joinery components		2.06	3.86	1.49	4.52
other wood manufactures		4.82	8.84	2.80	8.12
plaiting materials		2.70	4.96	1.95	5.80
wooden furniture		1.96	3.68	1.39	4.38
pulp, paper & board		0.90	2.09	0.21	1.20
processing of paper & board		2.05	4.02	1.42	5.27
printing & allied industries		3.60	6.57	2.33	7.28
rubber products		1.72	4.02	0.89	4.82
processing of plastics		1.28	2.46	0.50	1.72
jewellery		4.04	7.60	2.56	7.30
toys & sports		3.44	6.49	2.15	7.34
miscellaneous		4.77	8.74	2.74	8.46
time	1977	-0.02	-0.22	0.00	0.09
dummies	1978	-0.04	-0.59	0.00	0.01
	1979	0.03	0.49	0.06	1.39
	1980	0.04	0.58	0.07	1.64
	1981	0.13	1.86	0.12	2.65
	1982	0.11	1.48	0.09	2.10
	1983	0.16	2.14	0.14	3.15
	1984	0.13	1.69	0.12	2.56
	1985	0.19	2.38	0.11	2.29
	1986	0.19	2.45	0.13	2.81
	1987	0.24	3.23	0.15	3.29
	1988	0.29	3.85	0.19	3.97
	1989	0.28	3.54	0.18	3.59
Adjusted R squared		0.84		0.83	

Table 5b

Dependent variable	Gi		ln Gi	
	β	t value	β	t value
constant	-2.74	-6.12	-5.03	-6.87
X1	0.22	2.96	0.39	3.84
X2	0.06	2.69	1.41	1.64
X3	0.25	3.59	0.91	3.43
industry dummies:				
Drawing & cold rolling	1.46	3.20	0.93	4.19
processing of non ferrous metal	0.93	2.44	0.43	2.83
manuf of clay products	3.21	6.16	2.18	6.99
manuf of cement, lime & plaster	2.25	5.23	1.39	7.19
manuf concrete for construction	1.33	2.69	0.65	2.25
working of stone	4.31	8.54	2.55	7.93
manuf of glass & glassware	1.99	4.41	1.15	5.57
manuf of ceramic goods	3.24	6.68	1.93	8.04
manuf basic industrial chemicals	0.86	3.14	0.37	3.48
manuf of paint	3.28	7.13	1.90	8.47
manuf of pharmaceutical products	1.85	4.51	1.05	6.05
manuf soap & toilet preparations	1.23	3.01	0.60	3.53
founaries	1.82	3.79	1.11	4.58
secondary transform of metals	3.68	6.99	2.43	7.37
manuf of structural metals	1.91	3.87	1.38	4.78
boilermaking	3.57	7.36	2.14	8.23
manuf of tools	2.11	4.32	1.41	5.35
manuf of agricultural machinery	1.91	4.25	1.21	5.66
manuf of machine tools	3.47	6.87	2.16	7.75
manuf of textile machinery	3.76	8.07	2.06	9.25
manuf food & chemical machinery	2.44	5.01	1.58	6.26
manuf plant for mines	1.56	3.42	0.91	4.13
manuf of transmission equipment	2.81	5.97	1.68	7.48
other machinery:specific industry	4.10	8.44	2.26	9.09
manuf of other machinery	2.30	4.95	1.44	6.41
shipbuilding	1.75	4.51	1.02	6.33
railway & tramway rolling stock	3.53	10.51	1.72	12.50
meausuring instruments	4.15	8.24	2.34	8.89
slaughtering & preparing meats	2.50	5.27	1.65	6.72
processing of fruit & vegetables	2.10	4.58	1.40	6.15
processing of fish & sea foods	2.96	6.53	1.72	7.81
grain milling	2.30	4.69	1.74	6.05
bread & flour confectionary	3.15	6.63	1.91	7.88
cocoa, chocolate & sugar	1.58	3.97	0.79	4.84
animal & poultry foods	2.16	4.49	1.64	6.02
other food products	2.11	4.95	1.31	6.96
brewing & malting	4.45	8.99	2.39	9.51
manuf of soft drinks	1.44	3.09	0.94	3.85
wool industry	4.09	8.72	2.21	9.11
cotton industry	2.01	4.55	1.25	6.12
knitting industry	2.92	6.03	1.85	7.04

Table 5b continued

Dependent variable		Gi		ln Gi	
		β	t value	β	t value
industry dummies					
textile finishing		2.88	5.77	1.83	6.48
carpets & other floor coverings		4.30	9.82	2.10	10.49
miscellaneous textile industries		1.98	3.97	1.43	4.91
mass-produced footwear		4.49	9.17	2.44	9.03
ready made clothing		1.94	3.95	1.34	4.80
furs & fur goods		3.01	5.94	2.15	6.30
sawing & processing of wood		2.63	5.24	2.02	6.04
semi-finished wood products		2.50	5.27	1.68	6.61
carpentry & joinery components		2.05	4.12	1.49	4.91
other wood manufactures		4.27	8.39	2.58	8.08
plaiting materials		2.64	5.20	1.91	6.13
wooden furniture		1.80	3.62	1.29	4.40
pulp, paper & board		0.82	2.05	0.14	0.86
processing of paper & board		1.99	4.18	1.34	5.40
printing & allied industries		3.55	6.94	2.24	7.59
rubber products		1.67	4.17	0.86	5.07
processing of plastics		1.14	2.34	0.42	1.56
jewellery		4.34	8.75	2.58	7.99
toys & sports		3.28	6.63	2.03	7.48
miscellaneous		4.54	8.91	2.58	8.65
time	1977	0.00	-0.05	0.01	0.24
dummies	1978	-0.03	-0.42	0.00	0.09
	1979	0.04	0.61	0.05	1.37
	1980	0.07	0.97	0.08	1.89
	1981	0.16	2.39	0.12	3.01
	1982	0.15	2.19	0.11	2.58
	1983	0.21	2.99	0.16	3.83
	1984	0.19	2.61	0.14	3.25
	1985	0.22	3.06	0.13	2.90
	1986	0.21	2.92	0.14	3.28
	1987	0.27	3.90	0.17	3.93
	1988	0.32	4.55	0.20	4.57
	1989	0.33	4.42	0.20	4.30
Adjusted R squared		0.86		0.84	

CONCLUSIONS

The objective of this Thesis was to study the determinants and patterns of trade and specialisation in the manufacturing sectors of industrialised countries. Since many of these countries do not differ much in their technologies, relative factor endowments and preferences, I assume that countries are in fact the same in all of these respects in both of the theoretical Chapters. In Chapter 1, I assume that the countries only differ in size and analyse the relationship between the size of the country and the characteristics of the manufacturing goods it produces and trades. In Chapter 2, there are no differences between the two countries. I suppose that the agglomeration of two vertically linked industries in one location is given by history and then analyse what happens to the location of these industries when a new technology, incompatible with the old, becomes available. Chapter 3 is an empirical study of specialisation patterns in the manufacturing sector of EU countries. The purpose of this concluding Chapter is to review what we have learnt and to suggest directions for future research.

Chapter 1 showed that country size alone can be a basis for inter-industry trade in manufactures. I allowed the industries to have different factor intensities, transport costs and demand elasticities and then determined the pattern of specialisation and trade for each case in turn. When industries differ with respect to factor intensities, the large country is a net exporter of capital intensive goods and the small country is a net exporter of labour intensive goods, with capital flowing from the small country to the large country. When industries differ with respect to transport cost or demand elasticities, there are no capital movements. Even though the endowments of capital to labour remain the same there is inter-industry trade between the two countries with the large country a net exporter of high transport cost goods and the small country a net exporter of low transport cost goods. When industries differ with respect to demand elasticities the large country has positive net exports of high elasticity goods when integration levels are close to autarky or free trade levels; and it is a net importer of high elasticity goods at intermediate levels of integration.

In practice industries usually differ with respect to more than one characteristic. If the labour intensive industry is subject to higher trade costs than the capital intensive industry, then the large country is a net exporter of labour intensive goods at high levels of trade cost and capital flows from the large country to the small country; and this pattern is reversed at low levels of trade costs, with the large country a net exporter of capital intensive goods, and capital flowing from the small country to the large country. So we also have an explanation of why countries may change their pattern of specialisation.

Chapter 2 provides an explanation of why it is that at times of major technological breakthroughs a leading region may lose its dominant position to a lagging region. It draws on the insights from the economic geography literature to illustrate why two vertically linked imperfectly competitive industries might agglomerate in the one location. When a new technology arrives, it does not benefit from the existing agglomeration since it is assumed to be incompatible with the old technology. Consequently, it is more likely to be adopted in the lagging region which has lower wages. We also saw that it is possible that the two technologies can co-exist. The new technology region has more firms operating and hence a higher wage. The old technology region has less firms operating so the agglomeration benefits are lower, but this is offset by a lower wage enabling it to continue to compete with the new technological leader. These results raise policy questions for the region with the old technolgy. The government of that region could explore various options to ensure that the new technology is adopted immediately.

Chapter 3 showed that the degree of specialisation in the manufacturing sectors of some EU countries has increased between 1968 and 1990 and that the specialisation patterns have been consistent with the new trade theories based on scale economies, and the new economic geography theories based on vertical linkages between industries. There was only weak support for the Heckscher-Ohlin theory which was unsurprising since the five countries in the sample are fairly similar in terms of their relative factor endowments.

The insights and tools developed in the new trade theory and economic geography literature have been the main building blocks in both of the theoretical Chapters. Since the late 1970's, the trade theory literature has relied heavily on the use of Dixit-Stiglitz preferences which simplifies the analyses considerably and enables us to address questions which we were unable to before. One limitation of this modelling is that the firm's scale of operation is constant so we do not see the benefits of economies of scale. Chapter 1 would certainly benefit from a model which allowed the industries to differ in terms of their scale economies so that we can determine whether large countries will be net exporters of goods which are subject to large economies of scale.

Moreover, most of the trade literature has continued in its tradition of working with static models. Again, a lot is gained by keeping models simple but it is worth investigating what we could gain from adding dynamics. It is clear that a dynamic model would be a useful extension to Chapter 2. Within the static framework, Chapter 2 showed that there is an equilibrium with the original leading region operating with the old technology and the original lagging region operating with the new technology. But it did not show that this is the equilbrium. To do this we need a link between the two periods, that is we need to move from a static model to a dynamic one. This would certainly complicate the analysis but would be useful in identifying the circumstances in which technological leapfrogging will take place.

As well as the development of new theoretical tools, we also need to subject our models to rigorous testing. Although a rich trade data set is available the same cnnot be said for national data sets of many countries. Trade theories make predictions about production and trade so we also require disaggregated national data. Ideally, this would be disaggregated enough so we can reclassify industries in terms of economic definitions of industries instead of using the statisticians definition. Chapter 3 contains the most disaggregated national data set for the European Union countries but this was at the cost of only including five countries and a proportion of the manufacturing sector. Most other European Union empirical studies have relied exclusively on trade data or more aggregated groupings of industries.

Once we have a disaggregated national data set for European Union countries, we need to develop a good proxy of trade barriers, preferably for each country and each industry. Many trade theories relate the pattern of trade and specialisation to the level of trade barriers. In order to test these trade theories we need to know what the size of these trade barriers are. Chapter 3 was only able to show that the EU experience is consistent with trade theories.

So there is still a lot of work to be done in the development of tools and data reporting. Yet even with the tools and data at hand we are in a position to address important questions, as demonstrated in this Thesis. Chapter 1 has provided a start in determining the relationship between the size of a country and the characteristics of the goods it produces and trades. Even within the static framework, Chapter 2 showed that technological leapfrogging can occur just as a result of market interactions arising from pecuniary externalities. And finally, Chapter 3 showed that patterns of specialisation in some EU countries were consistent with what trade theories predict.

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