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Industry Relocation and Agglomeration in a Core, Adjacent, and Periphery Region Model As Applied to Spain

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Fundamental contributions to international trade theory in the last two decades greatly enhanced its ability to predict the industrial restructuring and the patterns of trade that followed trade liberalisation between countries. The introduction of the theories of economies of scale (Krugman, 1979), transportation costs (Krugman, 1980) and the location of production activities (Krugman, 1991b), into the new international trade theory resuscitated the theoretical and empirical works of economic geographers and regional economists (von Thünen, 1842; Pottier, 1963; Paelinck and Nijkamp, 1975). The core-periphery model (Krugman, 1991b) used two types of regions (a central, core, industrialised area and an agricultural, peripheral, resource area) to introduce the theory of economic geography and the endogenous location of manufacturing activity through the forces of agglomeration and dispersion. This model found that trade liberalisation encourages supplier and final goods producers to seek common geographic production locations close to central markets to achieve pecuniary agglomerate advantages in production (Krugman and Venables, 1996). Theoretical results using a model with these two types of regions found diversified agglomerate outcomes are possible under conditions of both perfect and imperfect labour mobility (Ludema and Wooton, 1997; Forslid and Wooton, 1999). In a further application of this two-region, core-periphery model, the Heckscher-Ohlin von-Thünen model found that a country's characteristics of location and resource endowments and its factor and transport intensity of commodities determined its spatial production activity (Venables and Limao, 2002). These theoretical results from a core-periphery model have established a rigorous basis for understanding and predicting effects of trade liberalisation between countries.

The empirical literature (Brülhart and Torstensson, 1996) accompanying this theoretical international trade literature has used industry concentration measures to examine the type of industries that will locate in central, industrialised regions. Relative and absolute concentration measures have been developed to determine whether industry location is determined by comparative advantage and specialisation or by economics of scale (Haaland *et.al.*, 1999). Forslid *et. al.*, (1999) develop an absolute concentration measure to predict industry behaviour by its characteristics. Midelfart *et. al.*, (2000) use the location-Gini (ascending order $0 \leq LG_{ij} \leq 0.5$) to measure the changing industry concentrations in the European Union (EU). This empirical research has shown the strong, home-market effects for core region industries that need economies of scale, forward and backward linkages, skilled labour inputs, and high expenditure shares (Haaland et. al., 1999; Davis and Weinstein, 1998, 1999; Forslid *et. al.*, 1999; Midelfart *et. al.*, 2000). The importance of industry characteristics interacting with country characteristics has been empirically verified (Midelfart *et. al.*, 2000).

In all, these empirical results have demonstrated the fundamental validity of the new international trade theory based on a model with two types of countries. These results show that industrial concentration in both core and periphery countries is either increasing or decreasing because of trade liberalisation. This conclusion implies, then, that agglomeration and dispersion forces have been at work among the economic regions within each country to produce the observed effects at the national level.

1.2 RESEARCH MOTIVATION AND OBJECTIVE

However, the empirical literature is absent of any analysis of the effects of trade liberalisation on regional manufacturing location within the regions within a country. The new economic geography theory argues the importance of industry concentration in the economic development of a country (Krugman and Venables, 1995). Yet, there has been no analysis of the effect of integration on the production structures and manufacturing locations, at the regional levels within the EU member-nations, in the face of declining barriers to trade and trade costs. Neither has there been an analysis of the effects of the endogenous forces on the micro-economic variables, such as wages, wage convergence, gross investment, and the costs of production.

The objective of this dissertation is to empirically examine the forces of agglomeration and dispersion inherent in the core periphery theory (Krugman, 1991b) at the regional level within EU member states and specifically analyse trade liberalisation effects in Spain.

1.2.1 The Core-Adjacent-Periphery (CAP) Model

Although much attention in the literature (Venables, 1994) focuses on the theory of agglomerates, agglomerate growth, and agglomerate stability, no empirical research has undertaken the task of defining and identifying the core regions in the EU. Agglomeration forces[1] work within a geographic area where cumulative causation creates accumulation (Venables, 1994). This dissertation introduces the concept of an ***agglomerate*** to define such a geographic area: *a region with one or more large urban population areas with industrial complexes.* An agglomerate is similar to Krugman's (1991a) description of a home market, which has finite geographic size where economic general equilibrium effects dictate agglomerate industrial composition. Industry relocation could thus lead to a regional process of internal differentiation and structural change among several agglomerates within a country.

The core periphery model with two types of regions needs to be expanded to include a third region type, in order to develop a national regional model. This dissertation extends the core-periphery model to include an 'adjacent' region by using a synthesis of von Thünen's (1823) concentric circle theory and the theoretical nomenclature used by regional economists to describe national region types (Paelinck and Nijkamp, 1975). In concentric circle theory the core region serves as the centre region and

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[1] The word *agglomerate* has its origin in the Latin word *agglomeratus*, the past participle of *agglomerare*, which means to heap up, join, to gather into a ball, mass or cluster (Merriam-Webster's *Collegiate Dictionary (10th/ed)*, Merriam-Webster Inc., 2000).

the periphery region is located in the second concentric circle around the centre. However, between these two extremes is an 'adjacent' region, located in the first concentric circle – the 'in-between' region – that borders on the core and periphery regions. This adjacent region enables an empirical analysis to reveal whether the industry expansion in a core region will accommodate those industries requiring strong forward and backward linkages and the benefits of pecuniary agglomerate advantage and a high final demand bias.

Von Thünen's (1823) concentric circle theory postulates that the transportation cost of market access reduces the level of sales revenues in direct relation to the distance between the location of production activity and the core region. Therefore, the further production activity is located away from the core region, the lower income and wages received will be. Concentric circle theory assumes that production activity is located in rings around the core region. Regional economists have classified national regions in these concentric circles, around a core region, as adjacent and periphery, based on their geographic distance from the core (Paelinck and Nijkamp, 1975). The national regional model developed in this dissertation is a synthesis of these two schools of thought and creates a framework for the analysis of agglomeration and dispersion forces.

The national three-region CAP model will fill the empirical gap by creating a framework within which the theoretical effects of agglomeration and dispersion forces can be measured *within* national borders. With a clear categorisation of region types and the identification of adjoining regions, an empirical analysis can examine convergence or divergence of industry structures over time. Using the CAP model, *one* regional industry concentration ratio measures both relative and absolute concentration, as well as measures the effects of agglomeration and dispersion forces between region types.

This three-region model is called the core, adjacent, periphery (CAP) model.

1.2.2 CAP Analysis of the European Union

The identification of regions of EU member countries allows them to be categorised for determining the centres of manufacturing location. This allows an exact identification of the EU geographic core regions, adjacent regions, and their periphery. Furthermore, it permits an empirical examination of von Thünen's concentric circle theory of an inverse relationship between income and distance from the centre.

The adjacent region allows for an expansion of industry with strong mutual interdependencies leading to the clustering of upstream and downstream industries in core and adjacent regions. The CAP model will allow us to identify the extent to which supplier and final goods producing industries cluster in adjoining regions (Krugman and Venables, 1996), and whether industry has become regionally more or less concentrated (Krugman, 1991a). The CAP model enables such an examination and highlights the importance of adjacent regions as buttresses for core agglomerates.

1.2.3 CAP Analysis of Spain

The choice of Spain as the country to which to apply the national regional model is motivated by four reasons.

First, Spain has been classified in the literature (Krugman and Venables, 1990) as an EU geographic periphery region subject to agglomeration forces from the EU geographic core. The objective of trade liberalisation policy is to catalyse economic development in national regions like Spain with self-sustaining manufacturing activities that reduce the export of regional unemployment. The new international trade and economic geography theories argue that a geographic periphery country should attract firms because of its favourable wage cost differential and high return on capital investment. A viable self-sufficient economy in Spain depends on the competition effect outweighing the home market effect of the geographic core. Spain therefore is of interest since the regional model reveals the micro-economic behaviour of firms to retain or become more cost efficient and competitive. Spain serves as an example of entrepreneurial behaviour in the face of trade liberalisation for a country relatively new in the EU.

Second, Midelfart *et. al.*, (2000) have found a greater spatial distribution of European manufacturing in the late 1980s and early 1990s. The authors suggest that a possible reason for this greater dispersion is due to the increased manufacturing concentration in the southern European countries. An increase in the overall level of industry concentration in Spain might explain the greater spatial distribution of European manufacturing. If industry concentration has increased in Spain, then an examination of changes in industry location in Spanish regions is valuable because it will reveal the location choice and characteristics of the new firms entering Spanish industrial sectors.

Third, trade liberalisation seeks to encourage industrial convergence between border regions (Krugman and Venables, 1996). Because Spanish regions border in the north on France and in the west on Portugal, a regional model analysis of Spain can assess the extent to which there has been a convergence or divergence in industrial structures and factor prices between these foreign region types (Krugman and Venables, 1996). Using the CAP model we will be able to examine whether trade liberalisation has stimulated convergence or divergence of industry structures among border periphery regions in adjoining foreign. It further allows for an examination of the contribution of agglomeration or dispersion forces to equalising factor prices between these region types.

Fourth, with three types of regions, the CAP model can identify multi-agglomerate production structures within a country. If several regional agglomerates are identified, then an analysis would show the clustering behaviour and location of supplier and final goods producers. If production structures between agglomerates have become more similar, then factor proportions have possibly become more similar due to perfect domestic labour mobility. Such a development would imply income convergence between regional core regions, but also would enhance the ability to predict the export industries of regional agglomerates. An application of the CAP model to Spain would discover whether such regional effects from EU trade liberalisation are present.

1.3 SUMMARY OF RESULTS

1.3.1 The Classification of CAP Regions for the European Union

The CAP model identified and classified region types as core, adjacent and periphery and their geographic location, according to a Eurostat population density definition of an urban agglomerate: five hundred people per square kilometre. The categorisation of the regions reveals 72 core regions, 69 adjacent regions, 68 periphery regions, and 13 island periphery regions in the fifteen-member country EU. Within the EU, the geographic centre is an uninterrupted series of core regions stretching from the west coast in the UK, through the Benelux and western Germany, to the northern regions of Italy. Several separate core regions exist at the edge of the EU, to the north, south, and west of its geographic centre.

The demographic analysis of EU CAP classification revealed net population relocation among regions of 5.8 million people between 1987 and 1989. Of this number, 5.1 million people relocated to core regions. Only the extreme periphery regions in the EU north and south experienced a population outflow. Population increased in most periphery regions, possibly due to new viable and profitable manufacturing activities that create new employment opportunities. This is a favourable outcome for the objectives of the new regional economic policy proposed by the Delores Committee (1989). At that time, fear was expressed that trade liberalisation would result in an export of unemployment from the periphery regions (Doyle, 1989).

The demographic evidence suggests a marginal population out migration in only two countries, Spain and Italy. This out migration is very marginal considering the total population size of these two countries. This outcome provides initial proof of the 'imperfect [international] labour mobility' assumption in the EU, as theorised by Ludema and Wooton (1997), supporting a divergent production outcome in the EU.

The economic data supports the concentric circle theory. There exists a significant difference in the levels of average per capita income in the CAP regions. The Tukey-Kramer test statistic for differences in means substantiated the significance of the income differences between regions. A positive correlation exits between income levels and regions types. The levels of per capita income are highest in the core regions and lowest in the island periphery regions. The data suggests a strong convergence between income levels in the periphery regions, further evidence pointing to the creation of new employment opportunities in the periphery regions.

1.3.2 Results from the CAP Model Applied to Spain

Trade liberalisation resulted in a decline in the number of firms in several industries: purification and distribution of water, food beverage and tobacco, and manufacturing of jewellery and musical instruments. Net declines occurred in the engineering sector: quarrying and mining of energy materials, fabricated metal products, and other transportation.

A number of industries have relocated between regions. The industry branch quarrying and mining of non-energy materials experienced a relocation of firms to the southern periphery regions, suggesting Heckscher-Ohlin comparative advantage. In the fabricated metal products branch, relocation occurred to the core and the adjacent regions, possibly for reasons of internal and external economies of scale, while in the wearing apparel branch firms relocated to all three types of regions. In general, the periphery regions experienced a *net* increase in the number of firms in the branches extraction and processing, engineering, and other manufacturing.

Trade liberalisation resulted in the entry of new firms in industry branches and industrial sectors. In general, all industry sectors experienced entry of new firms. However, there was not a uniform distribution of new firms over the regions of the CAP clusters. Firms do not automatically cluster in the core regions. It appears that the industrial structure – initial 'low' or 'high' shares – in regions determines, to a large extent, whether new firms locate in the core, adjacent, or periphery regions (Krugman and Venables, 1996). The regional model revealed the recomposition of industry in the core and adjacent regions in one of the CAP clusters, starting from 'low' initial levels of concentration. The recomposition consisted of a significant increase of new firms in the supplier industries. This development suggests an active regional industrial policy of attracting supplier industries, and stimulating the process of cumulative causation.

Industry relocation changed regional industry shares. Regions with initial 'high' or 'low' industry shares experienced a significant increase of new firms. This result is contrary to the outcome of Midelfart *et.al* (2002) for industry location in the EU. This analysis suggests that both intermediate and final good producing firms relocated primarily to core and adjacent regions with initial 'high' industry shares. A number of adjacent regions with initial relative high share positions retained these positions and experienced growth. This means that the process of agglomeration is occurring not only in core regions, but also in their adjacent regions, suggesting a convergence of industry structure between the core and adjacent regions thereby revealing a strong economic geography effect. In the four periphery regions of Asturias, Andalucia, Extremadura, and Murcia industry shares increased starting from 'low' initial levels signalling factor accumulation for industrial development.

The greater similarity between the core and adjacent regions due to the location of new firms and manufacturing labour is supported by the findings of the Krugman's (1991a) *industry index* of regional similarity or diversity. The statistical measurements reveal a convergence of regional industry structures in the CAP clusters after economic integration. The strength of the competition effect attributed to this growth of new firms in the adjacent regions significantly increasing industry structure similarity between these two region types. The competition effect also resulted in a greater similarity in industrial structures between adjacent and periphery regions. Finally, the analysis reveals there is a duplication of production structures in geographically separated regions. The production structure in Spain is polycentric.

The new *regional labour-land concentration ratio* verifies the polycentric production structure. The characteristics of the measurements are such that it meets the two requirements of; one, measuring industry concentration per region, and two, providing a clear cut-off point between absolute and relative concentration. These two characteristics make it the concentration measure of choice. The location-Gini, LG_{ij} measures industry concentration per region, but cannot distinguish between relative and absolute concentration. The Amiti (1997) and Forslid (1999) relative and absolute measurements are country and not region specific.

In 1997, fourteen of the twenty-three industries showed absolute concentration values. Of these fourteen industries, seven increased their absolute concentration, five dispersed industries became concentrated, and three industries showed a marginal decline in absolute concentration. The remaining nine industries showed relative concentration values. Of these, three absolutely concentrated industries became more dispersed, with the remaining six industries showing some positive and negative declines in their relative concentration values.

The regional labour-land concentration ratio suggests that on average industries experiencing absolute concentration are located in the core agglomerates and are characterised by low to medium final demand bias indicating strong economic geography home market effects, as found by Davis and Weinstein (1999). Industries with relative concentration ratios are located in core and adjacent regions and are characterised as industries in the dispersed – more/less – dispersed categories. On average, these industries show a medium to high final demand bias indicating the need for proximity to high domestic expenditures. These industries show a greater dispersion across the CAP clusters suggesting regional specialisation in production for domestic consumption.

The outcomes of the labour-land concentration ratio reinforce the industry index analysis of greater similarity in production structures between core and adjacent regions. It suggests the development of economic districts where economic structures transcend region boundaries. Multiple economic districts within the CAP clusters would lead to the deduction that these industries have commodities with high demand elasticities and high transport intensities dependent on *intra* and *inter*-industry inputs.

Spatial correlation analysis found the core regions in Spain to exert a strong home market effect as predicted by Krugman (1991b). These regions attracted the largest number of new firms and manufacturing labour. These events confirm the theory of economic geography, resulting in relatively higher wage and salary disbursements. Economies of scale in the core regions increased due to the relatively high levels of gross investment in manufacturing activity. Theory suggests an increase in new firms increases the supply of new product variety thereby reducing imported products bearing transportation costs. This results in a decline in the price index in the core and increases real wages (Krugman, 1991b).

Trade liberalisation had its most significant effect on structural adjustment in the adjacent regions. These adjacent regions experienced a relatively larger readjustment in the number of new firms versus the core regions. The data reveals a reversal in the total number of firms between the core and adjacent regions. Although the core acted as an attraction region, stimulating the process of agglomeration, the competition effect in the adjacent regions, created a strong convergence of the microeconomic variables, such as average number of employees per firm, average wages per employee, average wage cost per firm, average gross investment per firm, and average gross investment per employee.

The periphery regions experienced the relatively highest level of gross investment and high average gross investment per employee. The rates of change in these two variables exceeded those of the respective core regions, attesting to the profitability of new investments in these regions (Venables, 2000). Firms in the periphery expanded plant capacity to create economies of scale, and became relatively more capital intensive to enhance their competitive position. Although the periphery regions saw a decline in total manufacturing employment, there was a strong convergence with the core in average employee per firm indicating a greater similarity in the production structure. The growth of average wages exceeded that in the core regions, but remained relatively lower in absolute terms.

1.3.3 The CAP Model Applied to the Spanish, Portuguese, and French Border Regions

The analysis of trade liberalisation on border periphery regions reveals two sets of results; the first of these pertains to industry structures, and the second, concerns economic growth in the border regions.

First, the development of industry structures in the two sets of Spanish border regions contiguous to Portugal and France is unequal. Industry structures between the French and Spanish border regions show a marginal divergence. Industry structures between Spain and Portugal show a stronger convergence with the Portuguese border regions than with the regions in their own CAP cluster of Madrid.

Second, home market and competition effects are evident in the foreign border periphery regions. Increases in the number of new firms and the inflow of manufacturing labour in the Portuguese and French border regions exceeded those in Spain, which experienced a strong decline in these regions. This resulted in relative higher levels of wage disbursements in foreign border regions. Capital investment in the Portuguese core region was comparable to that of the three French adjacent regions. This resulted in a strong convergence in regional average gross investment per firm. Production structures converged between these regions as evidenced by average number of manufacturing employees per firm, and the average wage costs per firm. There was, however, no convergence of average wage per employee between the Spanish and Portuguese border periphery regions. Absolute wage levels in the Portuguese regions remained lower than the Spanish and French regions. However, there is significant convergence of average wage per employee between the Spanish and French adjacent regions suggesting Stolper-Samuelson factor-price equalisation effects.

1.4 ORGANISATION OF THE THESIS

The remaining thesis consists of six chapters, with appendices. Chapter 2 presents a review of the current literature of international trade theory, and an empirical literature review of published research in the field of the new economic geography. Chapter 3 defines the concepts and terms of economic integration used in the thesis. Chapter 4 contains the mathematical derivation of the CAP model, the identification and classification of the regions in the member states of the EU, and the demographic and economic facts from that classification that demonstrates the applicability of the three-region CAP model. Chapter 5 uses the CAP model for Spain to analyse the changes in firm location in the regions, the changes in regional industry shares, the changes in manufacturing employment in the regions, the industry similarity/diversity analysis, and changes in regional industry concentration using the new labour-land relative and absolute concentration ratio. Chapter 6 estimates the strength of agglomeration and dispersion forces between the CAP clusters of the Spanish regions using the spatial correlation coefficient. A similar analysis is undertaken for the Spanish, French, and Portuguese border periphery regions. Finally, Chapter 7 draws conclusions about the use of the CAP model to analyse the regional effects within a country from trade liberalisation.

CHAPTER 2
LITERATURE REVIEW

2.1 THEORETICAL LITERATURE REVIEW

2.1.1 Introduction

International trade theory describes the economic forces that determine the nature of exchange between sovereign nations. There are three main bodies of theoretical thought that explain the nature of exchange that is actually observed in the real world. The three themes are comparative advantage, the 'new' trade theory, and the 'new' economic geography. Each theme identifies a particular economic force. The driving forces underlying the theory of comparative advantage are perfect competition and the exogenous differences between sovereign countries resulting in *inter*-industry trade. In the 'new' trade theory, the underlying driving force is imperfect competition and its unique characteristic of internal returns to scale that explains *intra*-industry trade. Finally, the 'new' economic geography theme of international trade is based on endogenous differences between production locations due to trade costs, and examines the forces of agglomeration.

2.1.2 Comparative Advantage

In international trade theory the term *comparative advantage* means the ability to produce a product whose opportunity cost of production in terms of other goods is lower in one country than in the other country. The theme of comparative advantage is found in the trade models of Ricardo, and Heckscher-Ohlin. In the Ricardo model trade arises because of relative differences in technology. In the Heckscher-Ohlin (H-O) model the source of trade is based on relative differences in endowments of factors of production. In both models there are exogenous differences on the supply-side that create comparative advantage.

2.1.2.1 Ricardian Trade Model

In the Ricardian model, trade between nations is based on differences in technology for a given state of the art. The model assumes two countries (A and B) two products (X and Y); and one factor of production – labour (L). Labour requirements and costs are constant. It also assumes perfect competition so that labour is paid its value marginal product. In autarky each country produces both goods, with the relative prices of goods (P_X) and (P_Y) determined by their relative unit labour requirements or labour productivity. Trade occurs because of the relative price differences between the two countries in autarky.

The pattern of trade is determined by differences in labour productivity. If the per unit labour requirements in the production of good (X) in country (A) are lower than the per unit labour requirements in the production of good (X) in country (B), then the price of good (X) will be lower in country (A), and country (A) will have a comparative advantage in the production of good (X). In this case, country (A)

will export good (*X*) to country (*B*). Similarly, if country (*B*) has a comparative advantage in the production of good (*Y*), good (*Y*) will be exported to country (*A*). The result of the opening up of trade between the countries is that relative prices will be equalised, and each country will now specialise in the production of the good in which it has a relative comparative advantage. In general, the gains of trade are twofold: one, total world output increases due to specialisation in production by both countries; and two, consumers in both countries have a wider choice of products.

The Ricardian model of trade is unable to explain some aspects of trade, and is therefore limited in its predictive powers. One, it predicts complete specialisation even though the real world is characterised by many countries producing a similar good. Two, the model does not consider the effects of trade on the domestic distribution of income. Three, there is no allowance for differences in resource endowments as a reason for trade. Four, the model is based on the assumption of perfect competition, thereby neglecting economies of scale as a cause of trade. These issues will be addressed in subsequent models of international trade.

1.1.1 2.1.2.2 Heckscher – Ohlin Trade Model

The Heckscher - Ohlin model of international trade addresses the issue of trade based on relative differences in resource endowments. It postulates that a country will export the commodity whose production requires the intensive use of the nation's relatively abundant and cheap factor of production, and import the commodity whose production requires the intensive use of the nation's relatively scarce and expensive factor. The model is a supply-side model because it isolates the differences in relative factor endowments among nations as the determinant of comparative advantage and international trade.

The Heckscher-Ohlin model is based on a number of simplifying assumptions. The model assumes two countries, two products, and two factors of production (2 x 2 x 2). It assumes perfect competition and constant returns to scale in production in both countries. Tastes and technology are the same in both countries, with labour being perfectly mobile within countries but not between countries. The same respective commodities in each country are labour (*L*) and capital intensive (*K*). There are no transport costs, tariffs, or other obstructions to trade. There is full employment in both countries, as well as incomplete specialisation in production.

The model explains comparative advantage and states that the pretrade differences in relative prices between two countries are due to relative factor abundance. In autarky relative factor prices differ between countries. The factor abundant product in the respective countries will have the lower price and be traded. As trade is opened commodity prices are equalised. The Stolper-Samuelson theorem argues that trade will change factor prices between countries. An increase in the relative price of the tradable commodity will increase the demand for the abundant factor input and decrease the demand for the scarce factor. This results in an increase in the return to the abundant factor, and a lower return to the scarce factor in both countries, thereby changing income distribution. Trade will thus reduce the pretrade difference in factor rewards in the two countries, and eventually bring about factor price equalisation. Once relative commodity prices are equalised, relative factor prices will also be equalised between the two countries.

A drawback of the Heckscher-Ohlin model is its assumption of perfect competition and constant returns to scale. This limits the model's predictive ability with respect to *inter*-industry trade where capital-intensive products are exchanged for labour intensive products. It consists of an exchange of manufactured for agricultural products and thus reflects comparative advantage. Krugman and Obstfeld (2002) observe that the Heckscher-Ohlin model fails to explain the real pattern of international trade. An important shortcoming of the model is its failure to incorporate transportation costs. In reality, a considerable share of world trade occurs between highly industrialised countries with relatively similar factor endowments. The Heckscher-Ohlin model fails to explain trade in differentiated products produced under conditions of imperfect competition and economies of scale. This requires a new theoretical model of international trade.

2.1.3 The New International Trade Theory

The new international trade theory assumes a world with imperfectly competitive market structures. The market structures are characterised by monopolistic competition and oligopoly. The key feature that distinguishes oligopoly from monopolistic competition is that in the former the actions of one firm have a direct impact on those of the other. There are two main forms of oligopolistic competition; pure and differentiated oligopolies. Pure oligopoly consists of rivalry between a few firms in an industry that produce a standardized product. Examples of such products include; 'steel, aluminium, lead, copper, cement, rayon, fuel oil, plywood, tin cans, newsprint, explosives, and industrial alcohol.' A differentiated oligopoly is characterized by an industry with a few firms that dominate the market for a differentiated product. Examples of products from such industries are; 'automobiles, toothpaste, cereal, cigarettes, TV sets, electric razors, computers, farm implements, refrigerators, air conditioners, soft drinks, soap, and beer' (Thompson and Formby, 1993).

Pure oligopolistic competition with a standardised (homogenous) product is also known as Cournot competition. Duopoly refers to two firms *A* and *B* competing in an oligopolistic market. A Cournot duopoly is a quantity setting oligopoly where each firm determines its own profit-maximising level of output. Now, assume the two firms sell a homogenous product, have identical production costs, and divide the market equally. This means both firms face an identical demand for their product such that their average revenue, marginal revenue, average total cost, and marginal cost curves are identical. Both firms maximise profits where marginal cost equals marginal revenue. This means both firms charge an identical price for their product. Each firm has half of the industry demand.

If one firm *B* increases production, its own product price declines and the demand curve facing firm A shifts to left for every price-output combination. If firm A wants to sell the original fixed quantity, it has to lower its price. Firm *A* faces lower demand and marginal revenue curves for every price-output combination. The ultimate result in the market is, lower product prices and a lower optimum level of output. To avoid this sub-optimal outcome, each firm must be convinced about the behaviour of its rival. In the initial situation, each firm is maximising profits with the understanding that the rival firm is committed to producing the current level of output.

A differentiated oligopoly is characterised by a few firms producing imperfect substitutes. Bertrand duopoly is a price-setting oligopoly where each firm sets a profit-maximizing price with the belief that the price set by its rival is fixed. Assume price is higher than the equality of marginal revenue and marginal cost. Now, if firm *A* believes the price set by its rival *B* is fixed, then firm *A* can lower its price marginally below its rival and attract a larger market share. The reaction of firm *B* will be to lower its price and undercut the price of its rival. This process of undercutting each other will continue until the price is bid down to the point where there are zero profits.

Monopolistic competition is distinguished from oligopolistic market competition because it is characterised by many sellers, and focuses on product differentiation, price competition, and non-price competition in the form of product performance features, quality and service. A differentiated product is one whose attributes differ from competing products in satisfying a similar consumer need. Differentiated products provide the consumer with a variety of products to choose from. Many countries in the industrialised world have similar industries operating in markets characterised by imperfect and oligopolistic competition. Countries trade in these products to satisfy consumers' insatiable desire for variety. This results in international trade in similar products also known as *intra*-industry trade. The new international trade theory is one of *non*-comparative advantage. The 'new' theory was introduced and subsequently developed by Krugman (1979, 1980, and 1981).

2.1.3.1 Imperfect Competition and Economies of Scale

A drawback of the Heckscher-Ohlin model of international trade is the assumption of perfect competition and constant returns to scale technology. This limits its predictive accuracy as an international trade model. The model fails to explain trade between countries in similar manufactured products. This deficiency in international trade theory was eliminated by Krugman (1979), who showed that international trade in similar products can be generated through economies of scale in manufacturing. The author assumes a product market structure of Chamberlin monopolistic competition in a two-country world with identical tastes and technologies. The model has one factor of production - labour. This factor is being used at less than minimum economies of scale (MES) because of the size of the product market. The force driving the new trade model is economies of scale rather than factor endowments.

The Krugman (1979) model suggests three ways of increasing market size: an increase in the labour force, international trade, and labour migration. In autarky an increase in the labour force will result in an increase in both the number of firms, n, and the number of products, x, produced. The welfare effects of this growth are twofold; one, it increases real wages; and two; it increases consumer choice since the number of products increases.

The opening of trade – at zero transportation costs – between two countries with identical tastes and technologies results in an increase in the scale of production, the number of products available, and welfare. Since there are no barriers to trade, the effect of trade is the same as if each country experiences an increase in its labour force. Wage rates and product prices remain the same after trade. The important difference from the Heckscher-Ohlin model is, that in this case, economies of scale give rise to trade.

Third, if labour is perfectly mobile, and there are positive barriers to trade, migration will be induced by higher real wages and the desire for enhanced consumer choice. The region to which labour will migrate will be determined by the distribution of the population, initial economic conditions such as wages and prices, and the historical presence of increasing returns. This conclusion lays the foundation for 'cumulative causation' and the forces of agglomeration.

The model points out that under conditions of Chamberlin monopolistic competition economies of scale create a reason for international trade. International trade means larger markets and foreign demand allowing the full exploitation of economies of scale. Krugman (1979) notes, 'the effects of trade are similar to those of labour force growth and regional agglomeration.' The model demonstrates that Ricardian international difference in technology or Heckscher-Ohlin relative factor endowments are not necessary for trade to occur.

2.1.3.2 Internal Returns to Scale and Transportation Costs

In a subsequent paper, Krugman (1980) extends his formal development of a trade model with economies of scale by introducing transportation costs. The introduction of transport and trade costs into the theory of international trade contributed to making trade theory more realistic since these costs were assumed away in the Heckscher-Ohlin model. Transportation costs changes the previous outcome that wages remain constant. With the opening of trade, transportation costs lead to higher wages in the country with the largest population density. The reason for this development is that transportation costs make it more attractive for production to be located near the largest market. In the larger market a firm will be able to realise both (i) economies of scale, and (ii) minimize transport costs.

The author introduces the concept of the 'home market'[2] and defines it as a geographic location with a relatively higher population distribution, higher wages, and a higher relative demand for products. The development process of a home market is derived from a number of assumptions. Krugman (1980) assumes the existence of two symmetrical countries – Home and Foreign – with respect to their size, labour force, number of firms, products produced, demand functions, wages, prices, and output. The

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[2] Alfred Marshall (1920) has explained why the home market is attractive. It provides external economies of scale, a pooled market for skilled workers, the supply of industry specific inputs, and technological spillover effects.

assumption of equally sized labour forces is relaxed to study the process of the home market creation. The economic effect of a relative increase in the Home market's labour force is an increase in the number of firms, a rise in production levels, an increase in nominal wages, a rise in product diversification, and lower product prices resulting in higher real wages in the Home country. The reduction in Home prices increases the elasticity of substitution for Home products. Home becomes the larger market with a higher population, wages, and demand.

The introduction of transport costs between the two countries affects trade and production of a particular product. Transport costs mean that the price of Home imports for a similar product from Foreign will bear transportation cost raising the relative Home import price of that product. If the demand elasticity of substitution in the Home market between the domestic and the imported product is zero, then Home will specialize in the production of that particular good and export it to Foreign. If on the other hand, Foreign can offset the transportation cost of her exported product to Home through increased economies of scale, thereby reducing the export price, both countries may end up producing that product depending on the Home elasticity of substitution for product variety. In this case, incomplete specialisation will occur in both countries.

Krugman (1980) has shown how the decision to trade will become a choice involving a trade-off between transportation costs and the need for economies of scale. The possibility of incomplete specialization, and hence diversified production, will be higher, the higher are transportation costs and the lower the need for economies of scale. Finally, with incomplete specialisation, both countries will trade all classes of manufacturers. However, the country with the largest domestic demand for a particular product will be the net exporter of that product. Incomplete specialisation results in high levels of *intra*-industry trade between countries.

Having established the fact that trade in similar products can occur under conditions of imperfect competition, with economies of scale, and transportation costs, Krugman (1981a) makes three observations about the current pattern of world trade. First, there is substantial trade between countries with similar factor endowments. Second, international trade consists of exchange of similar products i.e. is *intra*-industry. Third, the expansion of world trade since the end of WWII has not resulted in 'sizeable reallocation of resources or income distribution effects'.

The author develops a model that assumes imperfect competition, product differentiation, and unexploited economies of scale in production to explain these three observations about real world trade. The model assumes no transportation costs and allows the author to examine the conditions under which countries with similar endowments engage in *intra*-industry trade, and why countries with dissimilar endowments engage in traditional Heckscher-Ohlin *inter*-industry type trade.

To examine the first two observations, Krugman (1981a) uses the Grubel-Lloyd index of *intra*-industry trade in combination with a factor proportions similarity index.

$$I = 1 - \frac{\left(\sum_k |X_k - M_k|\right)}{\left[\sum_k (X_k + M_k)\right]} \qquad I = [0,1]$$

where X_k represents the exports of a country in industry k, and M_k represents the imports in that industry. The value of the Grubel-Lloyd index will be unity if there is balanced trade between each industry, and zero if there is complete international specialisation. Krugman defines a factor proportionality index[3] z as:

$$z = 1 \qquad z = [0,1]$$

The value of the factor proportions index will be unity ($z = 1$) if factor proportions between countries are identical, and zero ($z = 0$) if they are completely dissimilar.

In answer to the first observation, that there is substantial trade between countries with similar factor endowments, Krugman's model shows that 'the ratio of trade to income is independent of factor proportions'. In other words, economies of scale and comparative advantage both generate trade. Krugman's second observation, that international trade is *intra*-industry in nature, is answered by the fact that if the Grubel-Lloyd *intra*-industry trade index and the factor proportions index are both equal to unity ($I = z = 1$), then trade is completely balanced between *industries*. In this case, the pattern of trade is *intra*-industry and generated by identical factor proportions in industries of both countries. If, on the other hand, both indices show a value equal to zero, then trade is not balanced between industries, indicating specialisation and trade based on factor proportion dissimilarities between industries.

Krugman's third observation addresses the welfare effects of trade. Whether or not factors gain from trade will depend on individual utility, wages, prices, and the number of substitutable products. The author notes that the welfare effect is determined by a distribution effect and a market size effect.

First, the model shows that factor price equalisation occurs. Real wages in industries engaging in *intra*-industry trade will remain constant in terms of their own industry. However, in terms of industries where trade is based on comparative advantage, their real wage may decline if it is an abundant factor industry. This is caused by product price increases in that industry. These products enter the domestic price index that rises, causing real wages in *intra*-industry trade type industries to decline. The reverse will hold true if it is a scarce factor industry.

Second, the market size effect refers to the increased number of products available whereby consumer choice is enhanced. The welfare effect will benefit the abundant factor. However, it is not clear

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[3] In a two country world consisting of a 'Home' and 'Foreign' the industry size in Home is given as $L_1 = 2 - z$, and $L_2 = z$, while in the Foreign country relative industry size is given by $L_1^* = z$ and $L_2^* = 2 - z$.

whether the scarce factor will be better off. To determine this the author looks at the elasticity of substitution between products.

The elasticity of substitution is determined by the degree of product differentiation. However, the degree of product differentiation reflects similarity or dissimilarity in factor proportions. If countries have similar factor proportions whereby products can be substantially differentiated, then both the abundant and the scarce factor will gain from trade. On the other hand, if products are not sufficiently differentiated – indicated by a high elasticity of substitution – then factor proportion are not similar enough, and whether the scarce factor gains will depend on the critical value that determines whether trade is of the *intra-* or *inter-*industry type. Finally, *intra-*industry trade results in lower levels of resource allocation and economic disruptions.

The importance of the Krugman (1979, 1980, 1981a) papers is their significant contribution not only to the theory of international trade, but also in their expository contribution to understanding the patterns of world trade. These patterns can now be explained by traditional theories of comparative advantage with constant returns to scale technology, as well as the new trade theory based on increasing returns to scale technology. However, Krugman has also introduced the concept of the home market as a geographic location for production, consumption, and export of products. This opens the door to the new theory of economic geography in the international trade literature.

2.1.4 The New Economic Geography

The traditional theory of international trade neglected the location of production and assumed that trade occurred between two points in space. The new economic geography theory, however, introduces production location by identifying the economic parameters that determine the location of production and the development of industrial structures. Krugman (1991b) introduces the new economic geography theory through the core periphery model[4] with production location as its central theme.

2.1.4.1 Krugman's (1991b) Basic Core periphery Model

A complete mathematical formulation of the Basic Core Periphery Model is presented in Appendix 2A for this chapter. Briefly, the model assumes that a sovereign country consists of two regions. Each region has two sectors of production activity - agriculture and manufacturing. The agricultural sector is one of perfect competition, producing a homogenous product under constant returns to scale technology. The sector employs agricultural labourers who are immobile between sectors. The unit labour requirement in agriculture is one. The manufacturing sector is characterised by imperfect competition, product differentiation, and increasing returns to scale technology. Manufacturing activity is located in both regions and employs interregionally mobile manufacturing workers.

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[4] The centre-periphery model was first introduced into regional economics by Pottier (1963). It was subsequently used by Friedmann (1966, 1972)

In the long run, labour is interested in wages, and will migrate to the region that offers the higher *real wage*. If labour migration leads to a similar supply of agricultural and manufacturing labour in both regions, real wages will converge. In this case, a diversified production structure emerges with production occurring in both regions. However, if labour migration results in a concentration of the manufacturing labour force in one region, the real wages will diverge between regions. Under this scenario, a 'core periphery' production structure emerges with manufacturing production occurring in the region with the highest population.

Krugman (1991b) notes that labour migration will initially have an ambiguous effect on the movement of relative wages because of opposing forces in the short run.

The first force is the *home market effect*. The region with the larger labour force population (L) will be the larger market, have the higher concentration of firms (n), and will have the higher level of wages (w) and income (Y). A higher concentration of firms means a larger choice of 'variety' of manufactured products. Increased competition in the home market reduces prices.

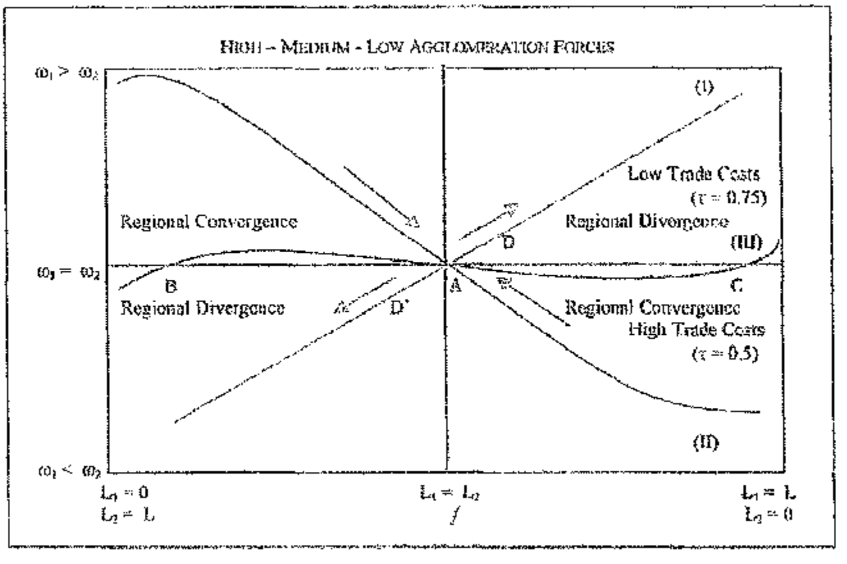
The second force is the *price index effect* that reinforces the home market effect since overall prices in the home market will decline as more firms (n) enter to produce for the local market. A price index measures the cost of a basket of goods in a particular geographic area. It includes imported goods. The larger the proportion of domestically produced goods to imported goods, the lower will be price index since fewer products include transport costs. Lower prices result in increased consumer surplus and welfare.

The third force is the *competition effect*. This refers to the increased competition for customers by the growing number of firms (n) in the home market. Price competition in the face of rising nominal wages puts downward pressure on profit margins until the breakeven point is reached. Since firms in the home market cannot force a lower nominal wage on labour to avoid this outcome, they elect to shut down and relocate to the periphery region to profit from the nominal wage differential. The competition effect is a dispersion force.

In the short run, the home market effect and the price index effect outweigh the competition effect since the *'real wage effect'* will cause real wages to rise in the core and decline in the periphery. The higher real wage is an incentive for manufacturing labour to migrate to the core region. As long as the real wage difference between regions persists the migration incentive will remain in favour of the home market, and a core periphery structure will develop. The incentive for manufacturing labour to migrate will be removed when the real wage differential is reduced. This can only come about through increases in (L) and (n) in the periphery regions, or through a reduction in real wages in the home market.

Krugman (1991b) identifies three parameters that will determine which of the above forces dominate in the long run and whether the system moves to convergence or divergence. The three parameters are: 'the share of expenditure on manufactured goods, μ; the elasticity of substitution among products, σ; and the fraction of goods shipped that arrives, τ'. Three labour demand / supply scenarios are developed under three varying transport cost values, τ. The high transport cost case, $\tau = 0.5$; low transport costs $\tau = 0.75$; and medium transport costs $\tau = 0.6$. The demand for labour is measured by the relative *real* wage rate: ω_1 / ω_2, where $\omega_i = w_i / P_i^{-\mu}$. The supply of labour is measured by $f = L_1 / \mu$. The results are depicted in Figure 2.1. In equilibrium at point A, manufacturing labour is equally distributed between the two regions so that $L_1 = L_2$ and $\omega_1 = \omega_2$. A situation of diversified production prevails, and the system is in equilibrium.

FIGURE 2.1
AGGLOMERATION FORCES



Source: Wooton (2001) based on Krugman (1991b), Figure 1.

Line (I) in Figure 2.1 illustrates the case of high agglomeration forces. At low trade costs, any movement from equilibrium at point A indicates an uneven distribution of the manufacturing labour force. In the case where $L_1 > L_2$, at point D to the right of equilibrium, the home market effect and the price effect will generate agglomeration forces resulting in a core periphery outcome with manufacturing concentration in region 1. The same forces will generate manufacturing concentration in region 2, had the initial labour shares been reversed, $L_2 > L_1$. The outcome is agglomeration and a core periphery structure of production.

In the case of high trade costs, line (II), if manufacturing labour, and hence firms, relocate to the region with the lower share of the manufacturing labour force, the competition effect will prevail, thereby equalising real wages in the two regions. High transportation costs leads to a diversified outcome with production concentration in both regions. The competition effect prevails when firms with low substitution elasticities, and high levels of unexploited economies of scale, move to compete in the region with the lower share of the manufacturing labour force. These firms service the core from the periphery regions. In the long run, as more firms relocate, they provide a counter balance to agglomeration forces.

Finally, line (III) in Figure 2.1 illustrates the case of multiple equilibria. Points B and C are equilibria where real wages between the regions are in equilibrium, but relative manufacturing labour force shares differ. Both points indicate that it is possible to have wage convergence between regions with different labour force shares, and hence manufacturing concentration. However, the equilibria B and C are not stable. Over the range of the curve BA and AC, the competition effect, wage convergence, and a diverse production structure dominate. Beyond points C and B the home market and price index effects lead to a core periphery outcome at the point where $L_1 = L$ or $L_2 = L$. In subsequent years, the Krugman's (1991b) core periphery model was normalised.

2.1.4.2 Normalising the Equations of the Core periphery Model

Fujita, Krugman, and Venables (1999) have normalised the core periphery model (Krugman, 1991b), and use it to illustrate how it can be employed to explain variations on the basic core periphery theme. These variations are found in the literature in the works of Krugman and Venables (1995), the writings of Puga (1996), Puga and Venables (1996), and the contribution of Forslid and Wooton (1999). The authors develop a common language, terms, and definitions to allow a thorough discussion of the range of issues found in the 'new economic geography' The normalised equations and the core periphery model are presented in detail in Appendix 2B of this chapter.

The significance of the new economic geography model lies in the identification of the economic forces that determine the endogenous location of manufacturing production. It complements the existing theoretical literature in allowing a better prediction of the pattern of trade between countries once a country's geographic location, resource endowments, manufacturing structures, and the costs of market access (trade costs) have been identified. The core periphery model, however, assumes perfect mobility of manufacturing labour between the regions. This assumption will always lead to a divergent production outcome. Subsequent theoretical literature examines the economic forces that militate against a core periphery outcome and ensure a diversified agglomeration production structure.

2.1.4.3 Diversified Agglomeration

The core periphery model illustrates how the home market effect and the price index effect lead to agglomeration and a concentrated production structure. In the model, the only countervailing force to agglomeration is provided by the competition effect. If strong enough, this effect leads to a diversified production outcome and a convergence of wages between the regions. The forces militating against an agglomerate outcome are; general equilibrium effects, wage differentials, less than perfect labour mobility, and comparative advantage.

(a) General Equilibrium Effects

Krugman and Venables (1990) explore the consequences of trade cost reductions on a small economy in a geographic core periphery setting. The authors assume a large market (the geographic core consisting of countries) and a small market (a periphery country) with high initial trade costs. A reduction in trade costs has five initial effects on the small economy. First, since the larger economy has more firms, there is an incentive for firms to relocate to the larger economy (home market effect). Second, firms in the smaller economy experience a decline in profits, and consumers a rise in prices. Third, production in the small economy will rise because of its access to a larger market. There is a reduction in net imports. Fourth, as trade costs come down, the price of imports from the larger economy decline. Since the small economy is a net importer of manufacturers, its domestic prices will also decline. Fifth, a decline in domestic and imported prices results in a gain in consumer surplus in the periphery country. It leaves producer surplus at zero because of free entry and exit. Social welfare increases. In the limit, as trade costs continue to fall, firms relocate to the larger economy, and supply the periphery from the core. Under these assumptions and conditions a core periphery outcome is obtained.

The authors examine the effects of two separate general equilibrium forces on the structure of production. First, they consider the effect on prices by assuming that transport costs of agricultural products are no longer zero. Instead, there are positive transport cost between the periphery and the core. The periphery has a larger agricultural sector than the core, so that the core becomes an importer of agricultural products. Transport costs make agricultural products more expensive in the core than the periphery. This raises the cost of living in the core vis-à-vis the periphery and is translated into higher manufacturing wages that puts the core at a relative cost disadvantage. Since there will always be transport costs between the core and periphery, the lower production costs in the periphery will attract firms. The outcome will be a divergent production structure and a convergence of incomes. The competition effect dominates.

The second general equilibrium effect that can change the core periphery outcome is the assumption that the supply of manufacturing labour is less than perfectly elastic in the core. Krugman and Venables (1990) further assume that factor endowments in the two economies are identical. As trade costs are reduced firms and manufacturing labour relocate from the periphery to the core. This reduces the factor endowment ratio in the periphery resulting in a larger share of the labour force employed in agriculture. Initially, the periphery region experiences a decline in manufacturing output, and a deterioration of its net import position.

The rising manufacturing labour costs in the core results in a wage discrepancy between the two regions. The wage difference and lower production costs in the periphery attract firms. Production in the periphery is increased resulting in a higher level of exports to the core and a reduction in net imports. The competition effect leads to a U-shaped production curve at some intermediate level of transport costs. As transport costs continue to decline, production continues to relocate to the periphery, output continues to increase, and a trade balance results when all trade costs are removed. The result is a divergent production structure and a convergence of wages between the regions. The general equilibrium effect works against concentration of production and an agglomerate outcome.

(b) Wage Differential

Anthony Venables (1994) remarks that the core periphery model (Krugman, 1991b) only considers the home market effect and its corresponding growth in demand as manufacturing labour and firms relocate to the core. The author observes that the core periphery model does not allow for the effect of 'cumulative causation'. This refers to the initial location of industry and the desire of firms to cluster i.e. to locate where other similar type firms are located. As firms locate where other have located before them, a clustering process develops, generating industry interdependencies and high levels of demand. Initial locations of production activity are caused by historical economic development or what Krugman (1991d) has called 'historical accident'. Firms want to locate close to large markets. The markets are largest where other firms have clustered. Relocation to these industrial clusters brings the advantage of the Marshallian triad of economic benefits; a generous qualified labour supply, a supply of intermediate products, and technological spillovers.

Venables (1994) argues that cumulative causation creates linkages between firms and industries that act as an attraction force[5] for other firms. The author argues that three types of linkages are created; one, a demand linkage; two, a cost linkage, and three, an input-output linkage. Each of the three linkages individually or in combination contributes to the forces of agglomeration. The demand linkage is created by labour mobility that leads to agglomeration. Market size is a positive function of the number of firms and manufacturing labour. The cost linkage is caused by technological externalities that result in lower input costs and hence production costs. The input-output linkage is caused by industry interdependencies. When industries use their own output as intermediate inputs, production structures create dependencies. The desire to be close to intermediate supplier industries creates agglomeration forces. In the latter case, both demand and cost linkages lead to industry concentration.

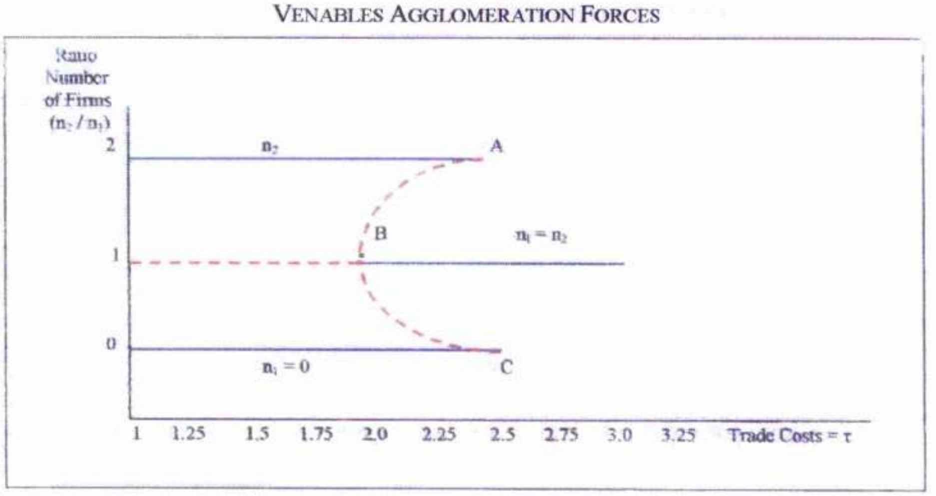
In a world characterised by imperfect competition and the need for intermediate inputs, agglomeration of industry will depend on three factors; one, the size of unexploited economies of scale, two, the need for input-output linkages, and three, the size of trade (transportation) costs. Venables notes that there is some critical trade cost value, τ, for a firm or industry that will cause it to relocate resulting in agglomeration, industry concentration, and a core periphery production structure. The process is illustrated in Figure 2.2.

[5] Attraction theory of growth centres was developed by regional economists who posited that input-output analysis describes the technical linkages between economic activities and is essentially demand-oriented. See Klaassen (1972), who argued that attraction forces between economic activities are formed by the existence of transportation and communication costs. Total transportation and communication costs of a certain activity, located in a certain region, are composed of input and output costs. Attraction theory describes the process of industry concentration.

In Figure 2.2, the ratio of the number of firms in each region is measured on the vertical axis. The level of trade costs is measured on the horizontal axis. The author assumes identical tastes, technology, and endowments between the two regions. In equilibrium, relative prices and wages are identical. Initially, there is a diversified production structure with the number of firms equally divided between the two regions, $n_1 = n_2$. Venables (1994) assumes that intermediate and final goods producers are located in each region, but that this distribution is not symmetric. Region one could produce intermediate goods demanded in region 2, and vice versa. This means that *intra*-industry trade is occurring between the regions.

At high trade costs (> 2.5) the system is stable with a diversified equilibrium, $n_1 = n_2$. In the intermediate range of trade costs (1.85 – 2.5), industry could have relocated entirely to either region 1 or to region 2. This means a stable agglomeration in whichever region industry locates. In this range there is also an unstable equilibrium. Any reduction in trade costs over this range will cause relocation. As trade costs drop below 1.85 there are two stable equilibria; point *A*, with industry concentrated in region 2, and an unstable diversified structure. The unstable diversified equilibrium is the result of the needs and behaviour of individual firms. There is some level of transport costs where individual firms, with given demand elasticities and input-output needs, relocate. The model does not indicate to which region industry will move causing an agglomerate outcome. The contribution that Venables (1994) makes to the core periphery model is the recognition that agglomeration is driven by the dependence of industry on intra- and / or inter-industry intermediate inputs. This need, combined with increasing returns to scale, magnifies agglomeration forces.

FIGURE 2.2
VENABLES AGGLOMERATION FORCES



Source: A. Venables (1994), Figure 4, p.12

Venables (1994), however, points out that in a general equilibrium context with wages endogenously determined, industry relocation will create a cost differential between regions that will dampen or even eliminate the forces of agglomeration. Agglomeration will be characterised by wage differentials between regions. This is illustrated in Figure 2.2. At zero and very high trade costs the system is stable, and equilibrium is characterised by $n_1 = n_2$. There is full-employment, an equal division of the number of firms each producing a differentiated product, and an equal demand for labour. Wages and prices are identical in both regions.

In the intermediate range, cost differentials between the two regions result in an unstable equilibrium up to point *B*, and two stable equilibria at *A* and *C*. At *A*, industry has concentrated in region 2, with no production in region 1. Venables notes that these results indicate that at zero trade costs industry location is determined by the supply of factors of production. At very high trade costs the home market effect plus the need (demand) for input-output structures dominate. At intermediate levels agglomeration forces dominate creating cost differentials since the region that gains industry will experience a real wage increase, while the region that loses industry experiences a real wage decline.

The significance of the Venables (1994) paper lies in the fact that he introduces the operation of the cumulative causation theme in the home market. Cumulative causation brings with it demand, cost, and input-output linkages that feed agglomeration forces. Agglomeration forces create wage differentials and general equilibrium effects that militate against agglomeration. Finally, the author introduces the theme of the lack of labour mobility between regions that can result in a diversified outcome.

(c) Labour Immobility

The models discussed so far (Krugman, 1991b; Krugman and Venables, 1990; Venables, 1994) have assumed free mobility of manufacturing labour between the regions that lead to agglomerate outcomes. The theme of labour immobility between regions and its effect on the endogenous location of manufacturing activity is considered in the papers of Krugman and Venables (1995), Krugman and Venables (1996), and Ludema and Wooton (1997). The theme of these papers is that less than perfect labour mobility will lead to a diversified agglomerate outcome.

Krugman and Venables (1995) consider the effect of labour immobility between countries and regions on the forces of agglomeration. The framework is a general equilibrium core periphery model. The authors focus on the input-output structural relationship between industries as the driving force of agglomeration instead of the demand linkages of the basic core periphery model. The model considers the fact that some countries have a larger industrial base than others. A larger industrial base implies a larger final goods-producing sector and a larger supplier goods industry. The latter means lower prices of intermediate inputs. As trade costs are reduced, the country becomes attractive for final goods producers because of the larger supplier industry and lower input prices. This, in turn, also makes the country more attractive for intermediate good suppliers. Agglomeration forces lead to manufacturing concentration in the larger country i.e. core country.

Production concentration in the core results in the de-industrialisation of the periphery countries. Real wages rise in the core country and decline in the periphery country, creating a cost differential with lower wages in the periphery. The process initially leads to a divergence in production structures and wages. As transportation costs continue to decline, the lower wages in the periphery make it attractive for firms to relocate. The lower transportation costs remove the disadvantage of being close to final markets and the accompanying forward and backward linkages. Industry relocation results in a re-industrialisation of the periphery and a convergence of real wages. The model emphasises the role of lower transportation costs and the need for input-output structures. The model reinforces the work of Venables (1994) and illustrates the inevitable diversified agglomerate outcome driven by lower production and transportation costs in the face of labour immobility.

Krugman and Venables (1996) examine the importance of industry agglomerations and input-output structures that result in regional specialisation in production.[6] They note that the basic core periphery model, based on imperfect competition, focused on the need for internal returns to scale as a force driving agglomeration. The introduction of input-output structures in industrial production brings with it the pecuniary benefits of *external* economies of scale. High trade barriers prevent complete industry specialisation in a core resulting in a diversified production structure with incomplete specialisation. The model is characterised by imperfect competition, and consists of two countries with similar resources, technology, and tastes. Each country has an industrial base producing both intermediates and final goods. Labour is immobile between countries, and requires adjustment time between domestic industries. Since labour is not assumed to be instantaneously mobile between industries, there is a domestic wage difference.

The model assumes the two countries are symmetric, as are the two industries. Both *intra-* and *inter*-industry trade is present with *intra*-industry trade exceeding *inter*-industry trade in both countries. With high barriers to trade, each country will maintain its industry structure producing both intermediate and final goods for domestic consumption. The industries remain symmetric.

With the reduction of trade barriers a recomposition of industrial structures in the two countries occurs. The authors note that the country with the '*initial stronger position*' in either the intermediate goods industry or the final goods producing industry will tend to attract firms in that industry. This starts the 'cumulative causation' process in the particular industry.

> *'Producers of final goods will find that the country with the larger industry supports a larger base of intermediate producers, lowering their costs sufficiently to enable them to export to other markets. Producers of intermediate goods will find that it is to their advantage to concentrate production near the large final goods industry.'*

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[6] The Krugman and Venables (1996) paper reflects the theme of the Tinbergen (1961; 1964) – Bos (1964) systems for general location analysis.

The result is that industries will cluster, and the composition of industrial structures within the two countries will change. The authors argue that if industries are initially distributed very unequally between the two countries, relocation results in self-reinforcing concentration and complete specialisation.

In their model, agglomeration occurs if the strength of *intra*-industry input-output linkages exceeds that of *inter*-industry linkages. This point confirms the Venables (1994) conclusion that agglomeration forces will be stronger the higher the need for input-output structures, cost and demand linkages. The range of critical values for transportation costs over which agglomeration forces will be strong, will be larger, the higher the share of *intra*-industry inputs, and the lower the elasticity of demand. Given that trade costs remain positive but not prohibitive (the intermediate range), a multiple-agglomerate outcome is possible with changed industrial structures. Complete specialisation will enhance *inter*-industry trade at the expense of *intra*-industry trade.

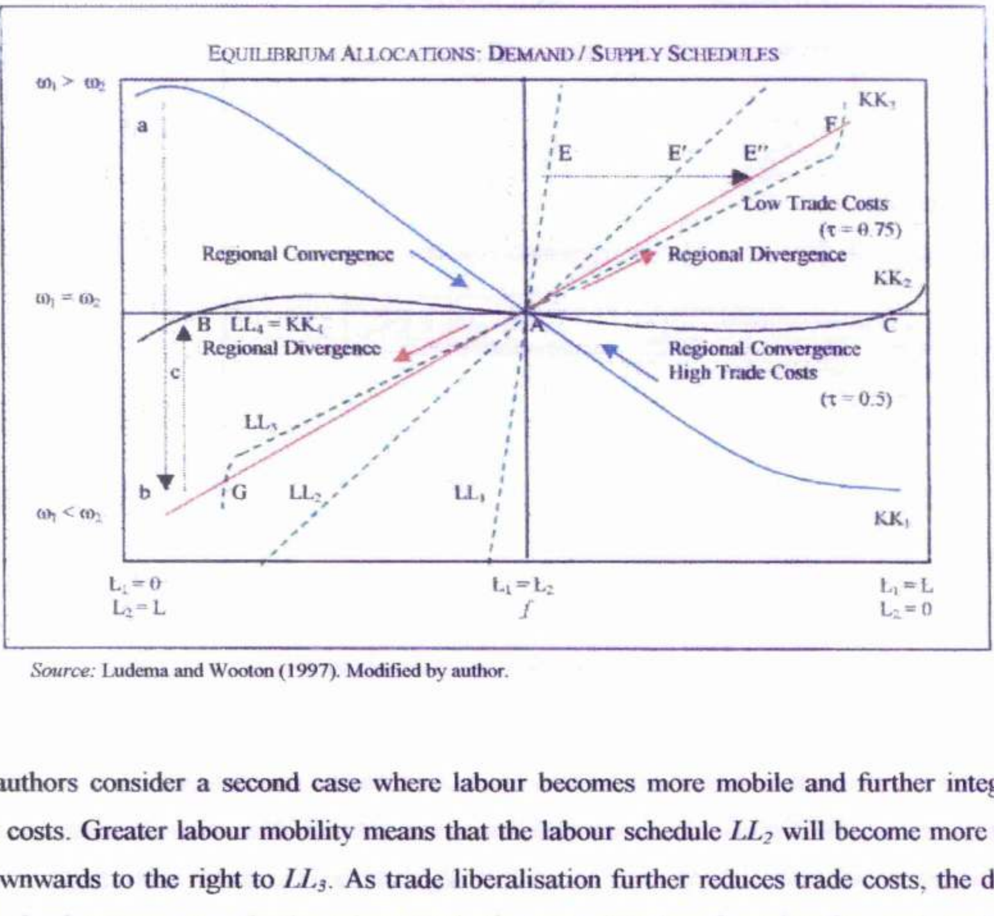
Ludema and Wooton (1997) illustrate that a diversified agglomerate outcome is possible by changing the labour mobility assumption in the core periphery model. It has been demonstrated (Venables, 1994; Krugman and Venables, 1996) that diversified agglomerate outcomes are possible under the assumptions of complete and incomplete labour mobility. Ludema and Wooton (1997) examine the outcomes of the Krugman (1991b) core periphery model by assuming labour is imperfectly mobile. All assumptions of the basic core periphery model remain the same. The authors relax the perfect labour mobility assumption and assume that labour has locational living preferences that mitigate their relocation desires. They demonstrate that 'imperfect labour mobility' will reduce the forces of agglomeration and result in higher wage differentials between the regions *within* a geographic area. The reduction of barriers to trade leads to the dynamics of an initial reduction in 'diversification, partial agglomeration, and a return to diversification.'

Their model leads to the estimation of three labour supply schedules; relatively inelastic, perfectly elastic, and one with an elasticity value lying between these two extremes. In Figure 2.3, the labour supply schedules, *LL*, are superimposed on the labour demand schedules, *KK*. Relative real wages are measured on the vertical axis, and the distribution of the labour force on the horizontal axis.

The uniform distribution of labour preferences is shown by the relatively inelastic labour supply curve, LL_1. Labour is hesitant (not perfectly inelastic) to relocate. It is the case of labour immobility. No amount of compensation will induce these workers to migrate. All other preferences exceed the wage preference. The perfectly elastic labour supply curve, LL_4, indicates worker locational indifferences between the two countries. Labour is perfectly mobile. There is no locational preference trade-off. Labour responds to the higher real wage as in the Krugman (1991b) model. The case of 'imperfect labour mobility' is shown by LL_3. In this case, labour is willing to consider relocating if the wage incentive is such that it minimizes or offsets the preference opportunity cost loss.

The slopes of the demand schedules reflect the level of transportation costs. At very high transportation costs the demand schedule slopes downward and there is a divergent outcome with wage convergence. As trade costs decline the demand schedule slopes upward, and with perfect labour mobility, LL_4, the system moves to a core periphery outcome. This outcome will always occur as long as the labour demand curve is steeper than the labour supply curve. The contribution of the authors is found in the situation where the supply schedule, LL_2, is steeper than the demand schedule KK_3. Any movement away from equilibrium to the right along the demand schedule creates an excess demand (EE″) and (E′E″) for labour that will not be satisfied because of labour preference intransigence. This means that the forces driving agglomeration, such as the 'home market effect' and 'cumulative causation' do not get an opportunity to develop. The result will be a diversified production structure.

FIGURE 2.3
EQUILIBRIUM ALLOCATIONS OF LABOUR SUPPLY AND DEMAND.



Source: Ludema and Wooton (1997). Modified by author.

The authors consider a second case where labour becomes more mobile and further integration reduces trade costs. Greater labour mobility means that the labour schedule LL_2 will become more elastic and rotate downwards to the right to LL_3. As trade liberalisation further reduces trade costs, the demand schedule KK_3 also becomes more elastic and rotates in the same direction. Complete free trade and labour mobility is indicated by the horizontal line $LL_4 = KK_4$. The line *ab* indicates the effect of trade cost reductions on the demand schedule, causing it to rotate from negative to positive. As trade costs decline and labour becomes more mobile, there may be a range of trade costs where the labour demand schedule becomes steeper than the labour supply schedule, such as LL_3. In this case, agglomeration forces are positive and are reinforced by the relocation of the most mobile workers. A 'partial agglomerated equilibrium' develops.

As trade costs decline, the demand schedule KK_3 becomes more elastic, so that as it rotates downward in the direction of KK_4 (shown by *c*), the supply schedule LL_3 becomes steeper, and excess demand develops, thereby weakening agglomeration tendencies. Strong worker preferences result in a re-migration to the region of origin. The long-run effect of greater trade liberalisation, assuming labour becomes more mobile is; one, a diversified outcome, followed by two, a partial agglomeration, and three, a return to diversification as trade costs are eliminated.

(d) Comparative Advantage

Traditional international trade theory considered differences in technological and resource endowments as the bases for trade. Given the new trade theory and the new economic geography models of trade, the question arises as to the current relevance of these theories. Krugman and Venables (1990) address this issue in a core periphery framework. The authors modify the original model by introducing two factors of production so that the two countries differ in market size and factor endowments. They further assume that the periphery is relatively labour abundant, with a comparative advantage in labour intensive manufacturing. They examine how comparative advantage in manufacturing interacts with lower trade costs and market access.

Their simulation results show that an initial reduction in trade barriers will cause the production of manufacturing output to decline. This is not an unexpected result, as firms, in a formerly segmented market, need to reorganise under the competitive pressures from market expansion. Agglomeration forces develop and the country becomes a net importer. This outcome is contrary to the predictions of the factor endowment model. As trade costs continue to decline, exports increase with a U-shape production outcome. At even lower trade costs, the periphery becomes a net exporter of manufactured goods, conform the prediction of the Heckscher-Ohlin model. So there appears to be an intermediate range of trade costs over which the periphery is a net importer. At a certain level of trade costs, the initial agglomeration forces reverse themselves and the competition effect dominates. There exists an initial wage difference between the periphery and the core due to comparative advantage. This wage difference increases as agglomeration forces dominate over the intermediate range of trade costs. However, as trade barriers continue to fall there will be wage convergence in the limit. The model suggests that initial reductions in trade barriers are accompanied by structural adjustments in the periphery. More importantly, the periphery does not experience de-industrialisation. Comparative advantage creates a diversified outcome with real wage equalisation as trade barriers are reduced to zero.

Forslid and Wooton (1999) develop a formal model to examine the role of traditional trade theory in a framework of imperfect competition, economies of scale, and location theory. Their objective is to study the extent to which comparative advantage creates a counterweight to agglomeration forces thereby contributing to a diversified production outcome. The analysis is developed in a Krugman (1991b) core periphery model with two modifications in the original assumptions. The authors assume all product varieties are mutually exclusive and that production costs differ between countries for all variety of products. These cost differences arise from comparative advantage due to production technology or factor abundance. Second, the assumption of an immobile agricultural labour force is removed. The forces of agglomeration will not depopulate a region because of the imperfect mobility of manufacturing labour (Ludema and Wooton, 1997). These assumptions provide a diversified production structure within which the forces of competitive advantage can be studied. With no barriers to trade, relative wages between the two countries will differ. The country with the lowest opportunity cost of producing a common product variety will have the higher relative wage rate. Relative wages will be unity when each region produces the same number of products and their labour force is equalised.

The dynamics of their model rests on the fact that with free trade i.e. no barriers to trade, agglomeration forces cease to operate. The system is stable. The movement of labour to the higher wage region will cause nominal wages to decline - an incentive for labour to relocate to its region of origin. If agglomeration forces are absent, industry locates according to comparative advantage and efficiency in production. The simulation results of their model revealed that when trade barriers are lowered, there comes a 'break' point when industry and manufacturing labour, dependent on comparative advantage, will relocate from the core to the periphery. At high trade costs, there is a diversified structure with manufacturing producing for local markets. At intermediate trade costs, agglomeration forces dominate and the system becomes unstable. At very low trade costs, comparative advantage dominates completely resulting in a diversified structure. This result is significant for peripheral regions since it dispels initial apprehensions of the EU Commission of the de-industrialisation of periphery regions (Doyle, 1988, Delores, 1989).

To summarise, the significant contribution of the new economic geography theory to the theory of international trade is the identification of the endogenous economic forces that determine a diversified or agglomerate production structure. The literature has shown that there are economic forces that militate against an agglomerate outcome. The literature has also shown that traditional comparative advantage theory and the new trade theory, combined, play a prominent role in the new economic geography theory in determining the endogenous location of manufacturing production. Venables and Limao (1999) use the themes of comparative advantage, and economic geography, to describe the forces determining international specialisation in production.

2.1.5 A Heckscher-Ohlin-von Thünen Model of International Specialisation.

Venables and Limao (2002) examine how distance and transportation costs determine the volume of trade, the pattern of trade, industry structure, factor prices, and the level of income across countries. Their theoretical model is based on the contributions to location theory by von Thünen (1826), and to international trade theory by Heckscher-Ohlin. The von Thünen model consists of a central location and a number of more remote locations where producers, located at progressively greater distances from the centre, receive lower prices for their products delivered to the centre, and pay more for products received from the centre. The Heckscher-Ohlin factor abundance theory assumes that locations can have a variety of fixed factor endowments used in the production of goods that determines a product's factor intensity. The authors note that, 'Combining these traditions gives outcomes determined by the interaction of two types of country characteristics with two types of commodity characteristics. The country characteristics are location and endowments of primary factors, and the commodity characteristics are transportation intensity and factor intensity.'[7]

The trade model developed by Venables and Limao (2002) assumes a world characterised by perfect competition with a constant returns to scale technology. The model assumes a central manufacturing location at the country level. This central location is defined as having, '(a) one good (or composite of goods) that is exported...(b) the central location imports all other tradable goods, and (c) all other locations can be arranged on a line going through the centre.' The manufactured product exported by the central region can be used for final consumption and as an intermediate good in production. Countries located away from the central country are endowed with two immobile factors of production – capital and labour. The model assumes three tradable goods, *X*, *Y* and *Z*. Good *X* is produced and exported from the centre, while goods *Y* and *Z* are produced in other countries and imported by the centre. The price of good *X* in the centre is unity and acts as the numeraire. Income in the centre is fixed in terms of good *X*. The model further assumes there is 'no interaction between economies on either side of this point [0, the central location].'[8] All tradable goods are subject to transportation costs. Consumers in each country consume all three products.

Venables and Limao (2002) introduce distance and transport costs into the Heckscher-Ohlin world by assuming that all production activity is located on a radius extending from a central location. These production locations are 'non-connected' countries where the 'relative endowments do not vary too much.' Countries are located in zones, with the size of each zone determined by supply and demand for goods being produced. Since tradables are subject to 'ice-berg' type transportation costs, prices on goods exported from the central location will rise exponentially with distance, as will the price of imports by the centre. The authors assume that labour is concentrated in the centre and declines in numbers, as production activity is located at a further distance from the centre. The reverse is true for capital, as labour endowments decline capital endowments increase.

The three products in the model are characterised by factor and transport intensity. Factor intensity refers to share of labour and capital used in the production of the good. Transport intensity refers to transport costs of intermediaries used in production, and the transport costs of market access to the centre. The location of production is determined by the location where a firm can minimise resource costs per unit sold, which includes reducing 'transport cost per unit value added.' All products are assumed to

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[7] Venables and Limao (2002), p. 2

have a combination of transport and factor intensity. Good *X* is labour intensive with low transport intensity. It is produces and exported by the centre. Good *Y* is highly labour intensive with a high transport intensity, and good *Z* is capital intensive with low transport intensity. Both products are produced in countries that radiate outward from the centre.

Given these assumptions, Venables and Limao (2002) show that production location of transport intensive goods will be close to the central country. The production of good *Y*, which has a high transport intensity and a high labour factor intensity – specialisation in production – will be produced in a location very close to the centre. The centre imports this product. As we move away from the centre along the radius of production locations, the endowment ratios change. There will be countries that produce both goods *Y* and *Z*. There will come a point along the radius where it becomes unprofitable for countries to export good *Y* to the centre since the share of transport costs per unit value added (transport intensity) increases production costs that exceed the price obtained for good *Y* at the centre. These countries will continue to produce good *Y* for domestic consumption, but not for export.

As endowments change in the locations across the radius moving outward from the centre, capital becomes relatively more abundant. This allows the production of good *Z* to grow across countries and reach a point where good *Z* is exported to the centre because of its low transport intensity and high capital factor share. There is a range of countries in the Heckscher-Ohlin world that show incomplete specialisation in production, yet export both products. However, as we move across this range away from the centre, countries in this range will begin to show a different production structure and pattern of trade due to the transport and factor intensities of the goods being produced. Incomplete specialisation remains, regardless of distance. However, the production structure of output can change as we move further out from the centre. In some cases only one product is exported because the transport intensity makes exporting the other good unprofitable. At subsequent locations, further removed from the centre, countries become self-sufficient in the production of all three goods. Venables and Limao (2002) point out that 'transport costs are more important relative to factor endowments the greater is the difference in factor intensities between the two products, and the higher are the elasticities of substitution between primary factors.'[9]

In the Heckscher-Ohlin world of two products, – goods *Y* and *Z* – and two inputs, capital and labour, as capital becomes more abundant its factor price will rise and that of labour decline. The authors show that real wages (incomes) decline, as production activities are located at a greater distance from the centre. This reduction in real wages is due to the higher share of transport costs in the value of trade at further distances. Venables and Limao (2002) point out that as transport costs decline, the locations of goods production may change because of their transport and factor intensities. The authors show that

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[8] *Ibid.*, p.4. Brackets inserted by the author.
[9] *Ibid.* p.13

transport cost reductions have a negative effect on real wages in locations close to centre, but a positive effect on real wages in more remote locations causing real income to increase there.

The model developed by Venables and Limao (2002) introduces transport cost to allow the model to make better predictions about industry structure, factor income, and the resulting pattern of trade. They draw three important conclusions. First, that in order to be able predict the structure of production and the pattern of trade a model must consider a country's geographic location, the factor endowment of the country, and both the factor and transport intensity of the product. Second, transportation costs are the cause of real income disparity between the centre and more remote regions. Reductions in transportation costs induce supply changes. These supply changes affect prices, and, depending on both factor and transport intensity, altering the terms of trade between the regions. Real incomes are reduced in regions close to the centre, but rise in more remote regions. Third, remote regions are attractive for the location of new industry since their factor prices have already discounted distance. The authors write; 'Choice of location depends on both the factor intensity and the transport intensity of the new activity, compared to these intensities in existing industries.'

In a companion paper, Venables (2000) examines the optimal location of capital in a Heckscher-Ohlin – von Thünen model (Venables and Limao, 2002). The objective of the paper is to answer the question, 'Where does industrial capital locate?' The model differs from Venables and Limao (2002) in that this paper focuses on sector specific factors and the mobility of factors of production. In this model, Venables assumes countries are endowed with the factors capital, labour, and land. Each country produces two goods – manufacturers and agriculture. The production of these goods requires labour, and the specific inputs land for agriculture, and capital in manufacturing. Capital is internationally mobile while labour and land are not internationally mobile. However, labour is intersectorally mobile within a country. All goods produced are subject to trade costs.

As in Venables and Limao (2002), trade costs create exponential price functions embodying distance. In a world of perfect competition these prices equal the marginal cost of production. Prices, production technology, and country endowments determine the production structure in a country, and the returns to factors of production in the form of wages w, land rent v, and the return to mobile capital r. These variables determine income in the respective countries.

Since countries are assumed to have different endowments, and since labour is assumed to be intersectorally mobile within countries, the employment structure within countries can vary between high levels of manufacturing employment or high levels of agricultural employment. A country with a relatively higher endowment in capital has a higher share of employment in manufacturing, while a country with a high endowment of land has a higher share of employment in agricultural production. As in Venables and Limao (2002), 'the effect of distance from the centre on the structure of production is given by the difference in transport intensities of the products in the two sectors.' Factor prices vary across countries because of the transport intensities of their products. The author shows that nominal wages and return to land is a declining function of distance from the centre, while the return to capital could be positive.

To answer the question of where capital locates, Venables (2000) sketches two cases on the assumption that endowments of land and capital are uniform across countries. The cases explore the return to capital as a function of the geographic centrality of a country. Case one, assumes the transport intensity of manufacturing products to exceed that of agricultural products. Since industries with high transport intensity have been proven to locate close to the centre, the return on capital, land, and labour will be lower in more remote locations. The existing capital will move from the remote locations and relocate to the centre. The remote locations lose manufacturing activity and increase agricultural production. There will be a divergence in wages between the geographic locations since agriculture is transport intensive.

In case two, the transport intensity of agriculture is assumed to exceed that of manufacturing. The capital stock relocates from the centre to the more remote countries, and because wages are low in these countries the return to capital will rise. If countries close to the centre now undertake agricultural production, wages and the return to land increases in these countries, while the return to capital declines. There will be a convergence of wages between countries, with remote countries specialising in manufacturing. So, the answer to the question Venables posed, is that capital flows to the regions with transport intensive products.

Venables (2000) considers the case where the capital stock is given for countries along the radius from the centre, and asks the question, "Where will [additional or new investment] locate?' In case one, capital flows into countries close to the centre, wages are bid up, and the return to capital and land declines. Manufacturing production is increased in these countries, agricultural production declines, and the demand for intermediates from the centre rise. In case two, the reverse occurs. If new capital flows into remote regions where initial returns to capital are high, the new inflow will reduce the rate of return to capital, manufacturing production in remote regions will expand, with the higher demand for labour driving up wages in remote regions. Wages converge with the centre. Finally, Venables (2000) notes, that there are countries along the radius at intermediate locations between the centre and remote countries where the returns on capital are at a level (interior maximum) between these two extremes. New capital will first flow to these countries. Foreign investment will flow to a subset of countries close to the centre depending on the relative transport intensity of their sectors.

Venables (2000) shows, that when comparing the optimal allocation of capital to the free market equilibrium allocation, for both case one and two scenarios, more capital will be allocated to the remote regions than the central ones. The author experiments with intermediate regions that differ in their locations and endowments relative to the centre. He finds an optimum allocation of capital in these countries will increase wages and the rate of return more than in other regions. The reason for this is twofold: one, they are relatively poorer thereby raising the value of capital; and two, 'the terms of trade effect is more important the larger are capital imports; giving a country a low initial endowment will tend to make imported capital a lager share of the overall capital stock, enabling the country to benefit more from the terms of trade.' Put differently, the capital inflow reduces returns to specific factors and raises the wage; the smaller the amount of specific factors by a country, the large will be its overall income gain.'

2.1.6 Conclusion of the Theoretical Literature Review

The distinguishing contributions to the theory of trade that have made the patterns of trade more predictable have been; the introduction of imperfect competition, internal and external economies of scale, the role of transportation costs, the similarity or diversity in factor proportions in determining *intra-* or *inter*-industry trade, home markets, the geographical location and distribution of production activity, distance, and the transport intensity of products. These contributions have not diminished the importance of the role of traditional comparative advantage, be it Ricardian technological advantage or Heckscher-Ohlin resource abundance. The combination of these theories contributes to the ability of international trade theory to explain the real world patterns of trade.

International trade theory has incorporated economic geography and the endogenous location of production. The relocation of firms, and even entire industries, is set in motion by the forces of agglomeration and dispersion in response to reductions in trade barriers and transportation costs. The new theory of international trade has resuscitated the theory of economic geography. The Heckscher-Ohlin-von Thünen model recognises the substance of regional growth theory as developed by the classical regional economists. The Venables and Limao (2002) and Venables (2000) modes apply to disconnected countries located in zones on a radius extending from a manufacturing intensive core country. The theme of their model is that incomes decline the greater the distance of production activity from the centre because of the discounted transport intensity of products.

. The forces of agglomeration and dispersion inherent in the two-country core periphery model are applicable to multi-country models, such as the models of Fujita, Krugman, and Venables (1999). The theory behind these models is applicable at the national regional levels. The development of a national multi-regional model would explain agglomeration, dispersion, and real income effects within the geographic confines of national borders. Such a model is useful since the economic shock of trade liberalisation initially impacts manufacturing production activity at the national regional level. The new economic geography theory is concerned with the endogenous location of industry. If the new trade theory purports to identify the geographic location of production activity, thereby increasing the predictability of the patterns of trade, income, and welfare, then a theoretical micro-regional framework must be developed to track the changes in the domestic location of production due to economic policy.

2.2 EMPIRICAL LITERATURE REVIEW

2.2.1 Introduction

The empirical literature is silent on the theoretical validity of the Krugman model at the European regional level. There is a lack of research on the spatial distribution, location, and concentration of production activities at the regional level within countries, or at the regional level within the new multi-regional geography of Europe. Research on production location, and its distribution throughout Europe has focused more on production location and relocation on a national level in the EU Member states, than on its regional concentration and dispersion. A summary overview of the empirical work done on the measures of industry concentration and their application to the United States and Europe is set out below.

2.2.2 Location Quota

In his analysis of the American Manufacturing Belt, Meyer (1983) used a measurement statistic called a 'location quota'[10] to measure urban manufacturing specialisation in production. His location quota was computed as follows:

$$LQ = (CM_i / CM_T)/(NM_i / NM_T) \tag{2.1}$$

where CM_i and CM_T are respectively a city's employment in industry i, and total manufacturing employment T, and NM_i and NM_T are respectively the national employment in industry i, and the total T manufacturing employment. The ratio (CM_i / CM_T) is a measurement of the share of industry i in the total of manufacturing employment in a city. The ratio (NM_i / NM_T) is a measurement of the total national share of manufacturing employment in industry i.

The location quota allowed Meyer to identify industrial specialisation in the urban agglomerates of the manufacturing belt. Meyer found a strong positive relationship to exist in an agglomerate between specialisation in consumer durable production and specialisation in supplier industries. Meyer stresses that backward (upstream) and forward (downstream) demand linkages developed, which contributed to regional industrialisation and agglomerate specialisation. Efficiencies in transportation and communication resulted in relocation of intermediate and final consumer durable goods producers to larger market areas.

2.2.3 The Cumulated 'location-Gini' coefficient

In an empirical study of industry location in the US, Krugman (1991a) uses the 'location-Gini coefficient' to measure manufacturing and manufacturing employment in the individual U.S. States. His

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[10] Meyer, *Op. Cit.*, Table 5.

study had a twofold objective; to determine first, how localised U.S. industry is, and second, which industries are highly concentrated. The 'location-Gini coefficient' requires the construction of a number of ratios required for the construction of the "location-Gini coefficient'.

The first ratio RS_{ij}^{ei} is region j's share of employment e in industry i. The ratio is calculated as follows:

$$RS_{ij}^{ei} = R_{ij}^{ei} / N_i^{ei} \tag{2.2}$$

where R_{ij}^{ei} is the total number of manufacturing labourers in industry i employed in region j, and N_i^{ei} is total national employment in industry i. The second ratio RS_j^{me} is region j's share of total regional manufacturing employment (me) in total national manufacturing employment. The ratio is calculated as follows:

$$RS_j^{me} = R_j^{me} / N^{me} \tag{2.3}$$

where R_j^{me} is total manufacturing employment (me) in region j, and N^{me} is total national manufacturing employment. The third ratio, LC_{ij}, is the 'location coefficient'. The 'location coefficient' used by Krugman (1991a) is the inverse of Meyers' (1983) 'location quota', and is required to rank the regions. The ratio uses equations (2.2) and (2.3).

$$LC_{i,j} = \left(RS_j^{me} / RS_{i,j}^{ei}\right) \tag{2.4}$$

The value of the 'location coefficient' is such that $0 \leq LC_{ij} \geq 1$. The value of the LC_{ij} coefficient is then used to rank – *in descending order* – each region, and its respective percentage employment share per industry, as well as its percentage share in total national manufacturing. The cumulated value of RS_j^{me} can be symbolised by $C(RS_j^{me})$ and that of RS_{ij}^{ei} by $C(RS_{ij}^{ei})$. The cumulated variables sum to 1. The cumulated values are then used to create a (cumulative) 'locational Gini coefficient' for a specific industry.

To calculate the locational Gini coefficients, we use the ratio presented by Jacobson and Andréosso-O'Callaghan (1996). The ratio [using our symbolism] is defined as follows:

$$C(LG_{ij}) = \frac{C(RS_{ij}^{ei})}{[C(RS_{ij}^{ei}) + C(RS_{j}^{me})]} \quad (2.5)$$

where $C(LG_{ij})$ is the value of the 'location-Gini coefficient', (LG_{ij}) for industry i in region j, with the symbol C indicating that the 'location-Gini' is measured with the cumulated values of the two respective variables. In the numerator, the term $C(RS_{ij}^{ei})$ represents the cumulated value of region j's shares of employment in industry i. In the denominator, the term $C(RS_{j}^{me})$ represents the cumulated value of region j's share of national manufacturing employment. The values of the "location-Gini coefficient" that are calculated with equation (2.5) are then used to construct the Lorenz curve (See Chapter 2, Appendix 2C). The 'location-Gini' is a relative measure of regional industry concentration since it relates the regions' shares of employment in industry i to the size of the regions' share in total national manufacturing employment.

The (cumulative) 'location-Gini coefficient' for an industry can have a value between 0.0 and 0.5. An industry that is not localised, but is simply spread out in proportion to overall employment, will have an index of 0. An industry that is concentrated in one region with a small share of overall employment will have an index value close to 0.5. These two limits on the values of the 'location-Gini coefficient' are the direct result of using the 'location coefficient' to rank the regions in *descending* order. By cumulating these values, the addition of the last region will result in the cumulated series to sum to 1. The last region added will have the highest industry concentration. This can be proven using the 'location coefficient' in equation (2.4).

$$LC_{ij} = \left(RS_{j}^{me} / RS_{ij}^{ei}\right)$$

The percentage values of both RS_{j}^{me} and RS_{ij}^{ei} are less than 1. If the value of the denominator is sufficiently large relative to the numerator, the value of the 'location coefficient' will become small taking on a value between 0 and 1. The value of the 'location coefficient' closest to zero will be the last value added in the cumulating process resulting in the cumulative values to sum to 1. A low value of the 'location coefficient' means that the percentage employment share of industry i in region j substantially exceeds the percentage share of region j's share in total national manufacturing. In other words, the regional manufacturing labour force is dominated by employment in a given industry concentrated in that region. The proof that the highest value, 0.5, of the 'locational Gini coefficient' indicates regional industry concentration lies in the fact that the cumulated values of the two variables of the last region both equal 1. When these values are substituted in equation (2.5), the 'location-Gini coefficient' will have a value of 0.5 (See Chapter 2, Appendix 2C, equation 2C.3).

The results of Krugman's' (1991a, pp. 129 – 131) study point out that many industries in the United States are indeed highly concentrated geographically, such as the automotive industry in Detroit;[11] Motor vehicles & equipment with an $LG_{371,MI,OH,DE} = 0.303$, at the NACE 3 classification level (371). The industries that are the most highly concentrated are the textile and textile-related industries. Krugman found: weaving mills and synthetics have an $LG_{222,GA,SC,NC} = 0.477$; weaving mills and cotton have an $LG_{221,SC,GA,NC} = 0.443$; yarn and thread mills have an $LG_{228,NC,GA,SC} = 0.428$; and finally, textile finishing, except wool have an $LG_{226,SC,NC,RI} = 0.410$. All of the textile and textile-related industries are located in adjoining states along the Eastern U.S. coast. Finally, the industry with the highest concentration is the reclaimed rubber industry with an $LG_{303,WY,WI,WV} = 0.5$. This industry is concentrated in geographically separated states in the West, Mid-West, and Eastern U.S.

2.2.4 The Non-Cumulated 'Location-Gini' Coefficient

Brülhart and Torstensson (1996) have used non-cumulated 'location-Gini coefficients' in order to 'capture the degree of concentration and dispersion of the EU industrial sectors.'[12] Their construction of the 'location-Gini coefficient' differs from that used by Krugman (1991a), in that they do not calculate a 'location coefficient', do not rank the regions under consideration in *descending* order, and therefore, do not cumulate the variables (See Chapter 2, Appendix 2C, Table 2C.1). Instead, they calculate regional industry employment shares and regional employment shares in national manufacturing employment as in equations (2.2) and (2.3). The value of these ratios, which all have values less than 1, is then substituted in a '*non-cumulated*' version of the 'location-Gini coefficient' ratio that is defined as follows:

$$LG_{ij} = \frac{RS_{ij}^{ei}}{RS_{ij}^{ei} + RS_{j}^{me}} \tag{2.6}$$

The 'location-Gini coefficients' calculated with equation (2.6) will have values in the range of 0 to 1. A value of $LG_{ij} \approx 0.0$, means that the ratio $RS_{ij}^{ei} \approx 0.0$ (is very small), and $RS_{j}^{me} \approx 1.0$ (is significantly larger). For example, if the regional share of employment in industry i is 1%, and the region's share in total national manufacturing employment is 90%, then $LG_{ij} = 0.011 \approx 0.0$. The value of $LG_{ij} \approx 1.0$ when the opposite holds $RS_{ij}^{ei} \approx 1.0$ and $RS_{j}^{me} \approx 0.0$. Using the same share values in the reverse order, the value of $LG_{ij} = 0.998 \approx 1.0$ indicating that industry i is highly concentrated in region j.

[11] *GA* = Georgia; *SC* = South Carolina; *NC* = North Carolina; *RI* = Rhode Island; *WY* = Wyoming; *WI* = Wisconsin; and, *WV* = West Virginia.
[12] Brülhart and Torstensson, *Op. Cit.*, p.14

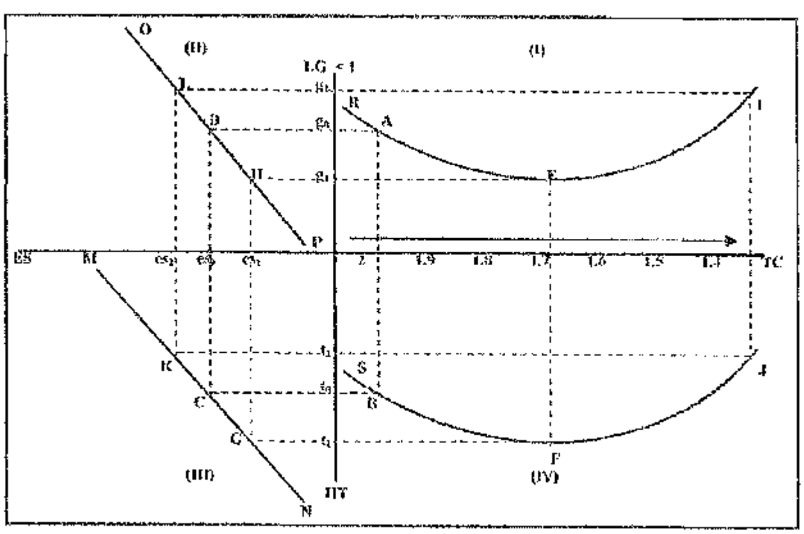
A value close to 1 indicates a high degree of manufacturing concentration or *inter*-industry specialisation. A value close to 0 indicates that a sector is not localised, but as Krugman has noted, is spread out in line with total manufacturing employment.

This calculation method has the practical property that it provides a cut-off value below which industry cannot be considered concentrated. A value of $LG_{ij} = 0.5$ means that $RS_{ij}^{ei} = RS_{j}^{me}$, whereas a $0.5 < LG_{ij} \leq 1$ suggests that $RS_{ij}^{ei} > RS_{j}^{me}$ and we can readily identify industry concentration, and revealed regional comparative advantage. Finally, the *non-cumulative* 'location-Gini coefficient' ranks the regions in the same order as the *cumulative* 'location-Gini coefficient'. A disadvantage of the latter method is that it fails to provide a cut-off point for the identification of industrial comparative advantage on a regional basis. The former allows for the ranking of regions according to the degree of comparative advantage, and their changing specialisation over time.

2.2.5 Economic Geography and Industry Concentration

Brülhart and Torstensson (1996) developed a theoretical model where the level of international trade depends on economic geography, and specifically, on the location and concentration of manufacturing activity. Their theory consists of four hypotheses, of which two relate to industry concentration, and two to *intra*-industry trade. Each hypothesis expresses a relationship between two variables. Each of these relationships can be graphed. The four graphs are illustrated in Figure 2.4. The two hypotheses relating to industry concentration are portrayed in quadrants (I) and (II). The two hypotheses relating to *intra*-industry trade are depicted in quadrants (III) and (IV).

FIGURE 2.4
INTEGRATION, CONCENTRATION, ECONOMIES OF SCALE, AND INTRA-INDUSTRY TRADE



Source: Author's diagram based on the theoretical model of Brülhart and Torstensson (1996)

Industry Concentration

In quadrant (I) we find Hypothesis (1). A quadratic relationship exits between industry concentration, LG_{ij}, and decreasing trade costs, *TC*. There is a range of declining trade costs *RF* that will induce firms to disperse and thus reduce industry concentration. However, as trade costs decline beyond this point, *F*, industry concentration increases.

Hypothesis (2) is found in quadrant (II). There exists a positive relationship between industry concentration LG_{ij} in the core, and the degree of economies of scale, *ES*. The more concentrated industry becomes in the core, the higher will be the required degree of economies of scale

Intra-Industry Trade

In quadrant (III), we depict Hypothesis (4). A negative relationship exists between increases in *intra*-industry trade, *IIT*, and the degree of economies of scale, *ES*. *Intra*-industry trade between countries is driven by the locational degree of available economies of scale.

In quadrant (IV), the relationship of Hypothesis (3) is illustrated with a quadratic function to depict the stages of economic integration. There is a range of declining trade costs, *SF*, in the initial stage of economic integration over which *intra*-industry trade increases. As trade costs decline beyond point *F*, furthering economic integration, *intra*-industry trade declines.

Theory of the Model

High trade costs result in a concentration of industry such as point *A* in quadrant (I). Industry concentration occurs in the core, with a given degree of economies of scale, es_0. High industry concentration is associated with a low level of economic integration, *B*, and a given level of intra-industry trade, t_0, as described by the rectangle *ABCD*.

Industry concentration in the core declines, g_1, as the costs of market access are reduced. Over the range *AE*, industries with intermediate trade costs, and requiring low degrees of economies of scale, es_1, will begin to disperse away from the core in the early stage of economic integration, *BF*. The dispersion of these industries results in a higher level, t_1, of *intra*-industry trade between countries. This intermediate cost scenario is represented by the rectangle *EFGH*.

Industries dependent on a high level of economies of scale, es_2, with low trade costs, will tend to concentrate in the core, g_2, as the costs of trade continue to decline over the range *FI*. Lower trade costs beyond the intermediate range are indicative of increased economic integration, *KJ*, and result in a lower level of *intra*-industry trade, t_0. The low cost scenario is represented by the rectangle *IJKL*.

Finally, There is an inverse relation between economies of scale and the elasticity of demand. A high demand elasticity implies a low level of unexploited economies of scale i.e. the firm is operating close to its minimum efficiency scale (MES). A high product demand elasticity means a fairly elastic demand curve tangent to the MES point of operations. A low demand elasticity implies a high level of unexploited economies of scale suggesting that the firm is operating high on its average cost curve to the left of MES. This inverse relationship implies that products of highly concentrated industries will have a high demand elasticity and low levels of unexploited economies of scale. Firm with a low demand elasticity and high levels of unexploited economies of scale will be more dispersed.

Empirical Evidence

In their empirical analysis, Brülhart and Torstensson (1996) borrow and develop variables for the estimation of their hypothesis concerning industry location and those concerning intra-industry trade. To determine the geographic core of the countries in their sample they use a 'centrality-index' coefficient derived from the 'peripherality-index' developed by Keeble *et al.* (1986). This measure needs to be estimated because their theory relates the degree of industry concentration to the core i.e. the 'centre' of the EU custom union. The authors calculate the non-cumulated value of the 'location-Gini coefficient' as defined in equation (2.6) as a measure of manufacturing concentration in the countries of their sample. The 'Gini' coefficient is estimated using manufacturing employment data for eighteen industries in eleven EU countries. The measures for economies of scale are taken from Pratten (1988) who had *ranked* industries 'in the order of importance of economies of scale for spreading development costs and for production costs'. The size of the firm, the type of product, and the length of the production runs determined the degree of economies of scale. The authors used this variable as a proxy for 'internal economies of scale'.

To test the hypothesis of a positive relationship between industry concentration and economies of scale, manufacturing industries were ranked in descending order according to the 'Gini' coefficient. Once ranked, each industry was associated with a number that reflected the 'ranking value' found by Pratten (1988) for each industry's degree of economies of scale. The authors used the Spearman rank statistic to test for the correlation between the ranked variables. The value of this statistic was 0.69, which is statistically significant at the 1% level. This lead the authors to conclude that there was a positive relationship between the ranked 'Gini' coefficients and the respective ranked economies of scale (IRS) values found by Pratten (1988).

The next step was to determine whether industries requiring a high degree of economies of scale are located in the core. This issue was determined by calculating the Pearson correlation coefficient between the calculated values of the 'centrality-index' and a country's employment share in a given industry – the location-Gini coefficient. The value of this statistic was interpreted as an indicator of 'locational bias' towards the core (central countries). A high value indicated a strong locational bias towards the centre since a country's employment share in that industry was relatively higher than in periphery countries. The statistic was calculated for 1980 and 1990 to detect changing values over time and then compared to the industry economies of scale rankings.

The authors found a rank correlation of 0.63 between industry economies of scale rankings and the locational bias coefficient. The correlation was found to be significant at the 1% level, indicating that industries with high levels of economies of scale are 'located in the central EU countries'. Finally, the authors found a strong correlation between industry concentration and their location in the 'central EU countries'. The more dependent industries are on scale economies, the more they are located in the core. These empirical results supported their two theorems of industry concentration.

The second set of hypothesis concerns the relationship between *intra*-industry trade (*IIT*), an industry's dependence on economies of scale, and the reduction in trade costs. The model hypothesised that *intra*-industry trade will decline as its dependence on a particular degree of economies of scale increased. To examine this issue, the authors relied on the work of Pratten (1988) and the OECD (1987). Both of these sources provided evidence of an inverse relationship between *intra*-industry trade and the degree of economies of scale. Pratten (1988) found that 'industries with high and intermediate economies of scale exhibit consistently lower *intra*-industry trade than industries with low scale economies'. The OECD (1987) data showed that 'scale intensive industries.... display consistently and significantly lower *intra*-industry trade than the average'. This evidence (Brülhart and Torstensson, 1996, Table 3) supports the theory of their model.

The same data also suggests a reversal in *intra*-industry trade patterns since WWII due to the relocation of industries dependent on high degrees of economies of scale. The authors find that in the early years of the EU customs union there was a dispersion of industries to the EU periphery countries. This trend, however, reversed itself in the 1980s, with a contraction of industry concentration in the periphery countries. The lowering of high Non-Tariff Barriers (*NTBs*), and hence trade costs, resulted in the relocation to the central countries of industries dependent on high internal returns to scale (*IRS*), thus reducing *IIT*. The reduction in *IIT* is the result of the presence of upstream and downstream industries in the core, reducing the need for dependence on trade.

The authors conclude that industries requiring a high degree of internal returns to scale will locate in the centre. The periphery countries will specialise in manufacturing activities requiring very low or no economies of scale, and non-manufacturing activity such as the service industry. Their theoretical and empirical results lead to the conclusion that these regions would experience de-industrialisation and an elimination of *intra*-industry trade. The authors admit that a disadvantage of their empirical estimations is their assumption that economies of scale across industries remain constant over time. There is no current data available on 'changes in minimum efficient plant scales'.

A final observation on the location-Gini coefficient is in order. The location-Gini coefficient is a statistic that measures relative concentration. In the Brülhart and Torstensson (1996) model, the statistic measures the relative concentration of manufacturing labour per industry and per country. However, we may question the role of the location-Gini coefficient as a relative measure of labour-intensive industries. Although there may be a relative abundance of labour in a particular industry in a given country, there may also be a relatively greater concentration of the respective number firms in that industry. Since there are a large number of firms, it would not necessarily mean that the industry is labour intensive. A capital-intensive industry may have clustered, and because of the relative size of its concentration, may result in a relatively higher number of manufacturing employees in the industry. A concentration measure reflecting an industry's capital/labour ratio might be more informative and should be given some consideration. Nevertheless, Brülhart and Torstensson (1996) have taken the first empirical step in examining the determinants that explain changes in industry concentration.

2.2.6 Economic Geography: Relative and Absolute Industry Concentration

Haaland, Kind, Midelfart-Knarvik, and Torstensson (1999) recognise the three themes in the new international trade theory that constitute the forces of industry concentration. In the Heckscher-Ohlin model, concentration occurs through comparative advantage originating from relative resource endowments that leads to specialisation in production. The new trade theory attributes concentration to increasing returns to scale and demand density. The new economic geography focuses on agglomeration due to the clustering of industries. The authors emphasise the need to develop a statistic that measures concentration attributable to the above elements of trade theory. They recognise the empirical limitation of Brülhart and Torstensson's (1996) use of the 'location-Gini coefficient' as a concentration measure

Theory

Haaland *et al.* (1999) propose two measures of industry concentration; relative and absolute concentration. The authors theorise that 'an industry is *relatively* concentrated if it differs from the average spread of production between countries; it has a high degree of *absolute* concentration if it is unevenly distributed between the countries.'[13] They theorise that country size plays an important role in the choice of concentration measure. If countries are of identical size, then the values of relative and absolute concentration will be the same. If countries differ in size, these values will diverge. They further postulate that 'high relative concentration of an industry implies a high degree of country specialisation [and comparative advantage], while this is not necessarily the case when there is high absolute concentration.'[14] The reason for the distinction in the industry concentration measures is to be able to make better predictions with respect to the theory of comparative advantage, the new trade theory, and the new economic geography. The theories of comparative advantage and specialisation relies on relative concentration of industry, while scale economies, *intra*-industry trade, and agglomeration is measured by absolute concentration. The authors propose to unravel Brülhart and Torstensson's (1996) dual function of the locational-Gini coefficient.

Haaland *et al.* (1999) use Amiti's (1997) formulation of the relative concentration index.

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[13] Torstensson *et al.*, *Op. Cit.*, p. 2

$$S_i^R = \sqrt{\frac{1}{c}\sum_j \left(s_{ij} - s_j\right)^2} \qquad (2.7)$$

where s_{ij} is the share of production in industry i carried out in country j, s_j is country j's share in total production, and c is the population number of countries. The index is known as a relative measure because the share of industry employment is related to the size of the country's share in total EU manufacturing employment. A high value for the relative concentration index indicates greater industry specialisation. A value of $S_i^R > 1.0$ indicates that industry i is more concentrated than the average industry.

The index of absolute concentration is defined and constructed in the following manner:

$$S_i^A = \sqrt{\frac{1}{c}\sum_j \left(s_{ij}\right)^2} \qquad (2.8)$$

The statistical measure in equation (2.8) does not adjust for country size.[15] It is significant to point out that both the relative and absolute measures of concentration refer to individual industries i, and do not indicate country location j. The authors focus on two measures of industry concentration and set out to empirically examine the determinants of these two concentration ratios.

The Theoretical Model

The objective of the study of Haaland *et al.* (1999) is to identify the determinants of the relative and the absolute industry concentration measures. They postulate that the relative concentration ratio indicates industries with comparative advantage, while the absolute concentration indicates industries with economies of scale. The authors specify the following theoretical model for relative industry concentration that captures the three forces of industry concentration.

$$S_i^R = \alpha + \beta_1 LAB_i + \beta_2 HCAP_i + \beta_3 TECDIF_i + \beta_4 EXPEN_i^R + \beta_5 SCEC_i + \beta_6 IO_i + \beta_7 NTB_i \qquad (2.9)$$

The forces of the traditional Heckscher-Ohlin theory indicating different relative factor intensities resulting in production specialisation and concentration are captured by the variables LAB_i and $HCAP_i$. The variable LAB_i measures relative labour intensities in the different industries, and the variable $HCAP_i$

[14] *Ibid.*, p.2
[15] *Ibid.*, p. 3. Haaland *et al.* (1999) point out that industry size can be measured by 'production (output), value added, or employment.

measures relative human capital intensities in industry *i*. The variable $TECDIF_i$ captures Ricardian relative differences in technology between industries. Relative technology differences give rise to 'comparative advantage and specialisation' in production leading to industry concentration. The new trade theory is captured by the two variables relative expenditure $EXPEN_i^R$ as a proxy for the 'home-market' effect and demand density, and the variable $SCEC_i$ measuring economies of scale. Industries dependent on a high degree of economies of scale tend to be more concentrated (Brülhart and Torstensson, 1996). The two variables input-output (IO) linkages between industries, and non-tariff barriers, NTBs, capture the new economic geography forces. Input-output structures are important for the clustering behaviour of firms encouraging the forces of agglomeration, and hence, industry concentration. The variable NTB_i represents trade costs for industries, the authors theorise a positive relationship between lowering of trade costs and industry concentration.

Empirical Estimations

The empirical results consist of calculating the relative- and absolute concentration ratios, and estimating their theoretical model. For the two period under consideration, 1985 and 1992, the relative concentration index has shown the most change in the ranking of industries, suggesting that the forces of comparative advantage cause concentration. The absolute concentration index has indicated little or no change in the ranking of some industries, from which the authors conclude that these industries are localised in large countries. They also find that some industries are concentrated in relative terms, but not in absolute terms, leading to the conclusion 'that some small countries are specialised in these industries.'[16]

Relative Concentration

Haaland *et al.* (1999) estimated the determinants of the *relative* concentration ratio, equation (2.9) using OLS and 2SLS. The strongest regression results were found for 1992 and 1985 using OLS log-estimations. The 1992 estimations are found in equation (2.9a) and the 1985 estimates in equation (2.9b). The calculated *t*-values are presented in brackets below the estimated coefficients.

$$S_i^R = \underset{(-1.486)}{-1.0063} + \underset{(1.902)}{0.0618}.LAB_i + \underset{(2.517)}{0.0886}.HCAP_i - \underset{(-0.046)}{0.00259}.TECDIF_i + \underset{(8.927)}{0.7454}.EXPEN_i^R - \underset{(-2.041)}{0.1618}.SCEC_i$$

$$+ \underset{(0.871)}{0.0521}.IO_i + \underset{(0.210)}{0.019}.NTB_i \qquad (2.9a)$$

$R^2 = 0.89 \quad \overline{R}^2 = 0.86 \quad n = 35 \quad df = 27$

[16] *Ibid.*, p. 16

The 1985 estimations;

$$S_i^R = \underset{(-1.690)}{-2.0061} - \underset{(-0267)}{0.0104}.LAB_i + \underset{(1.868)}{0.1401}.HCAP_i + \underset{(0.104)}{0.00785}.TECDIF_i + \underset{(6.104)}{0.7698}.EXPEN_i^R - \underset{(-1.056)}{0.1293}.SCEC_i$$

$$+ \underset{(0.678)}{0.067}.IO_i - \underset{(-0.246)}{0.0422}.NTB_i \qquad (2.9b)$$

$$R^2 = 0.76 \; \bar{R}^2 = 0.69 \quad n = 35 \quad df = 27$$

The estimated equations of the Haaland *et al.* (1999) model reveal different results for the two years under consideration. The 1985 estimations of equation (2.9b) have the wrong signs on the labour LAB_i and economics of scale $SCEC_i$ coefficients. Only two of the independent variables are significant in explaining the variation in the relative concentration ratio. The relative expenditure $EXPEN_i^R$ coefficient is significant at the 1% level, and the coefficient on the human capital $HCAP_i$ coefficient is significant at 10%.

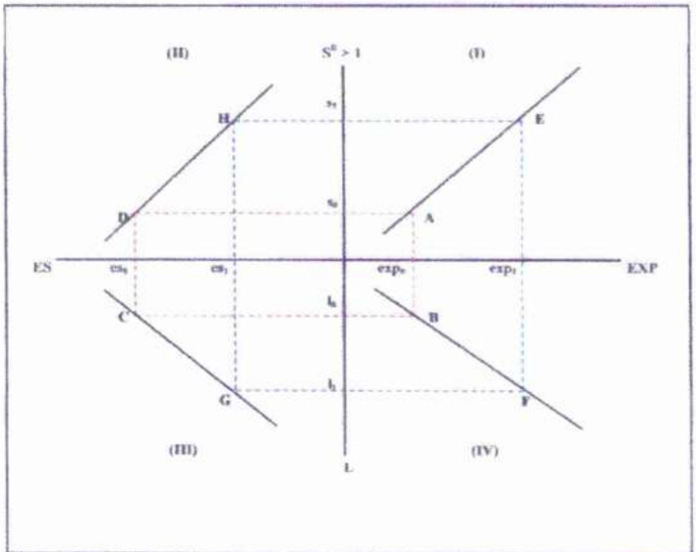
A test of the same structural equation (2.9a) for 1992 showed results that are more promising. Estimated coefficients on three of the independent variables are significant. The relative expenditure $EXPEN_i^R$ coefficient is significant at the 1% level, the coefficient on the human capital $HCAP_i$ coefficient is significant at 1% level, and the labour LAB_i coefficient is significant at the 10% level. Although the sign on the economies of scale $SCEC_i$ coefficient is negative (i.e. contrary to expectations), the coefficient is significant at the 10% level. The remaining variables in the specified equation for relative concentration are insignificant.

The estimated equation for 1992 has a correlation coefficient of $R^2 = 0.89$, and an adjusted correlation coefficient of $\bar{R}^2 = 0.86$ as compared to the 1985 test results of respectively $R^2 = 0.76$ and $\bar{R}^2 = 0.69$. The authors contribute the improvement in the test estimates to the effects of economic integration. The significance of the labour coefficient in the 1992 estimate suggests that the 'degree of labour intensity' has become more significant in explaining the variations in the relative concentration measure. The authors conclude 'that the completion of the internal market has allowed for increased specialisation in accordance with comparative advantage in labour intensive products'. The model shows that the relative concentration ratio is determined by Heckscher-Ohlin relative factor endowments and by the size of the - home-market an element of the new trade theory. The coefficients of variables unskilled- and skilled labour, and expenditure are all significant.

Relative Industry Concentration Model

The dynamics of the relative concentration model of Haaland *et al.* (1999) is captured below in Figure 2.5.

FIGURE 2.5
RELATIVE INDUSTRY CONCENTRATION



Source: Author's diagram based on the work of Haaland *et al.* *(1999)*

The positive relationship between relative concentration and the localisation of expenditure is presented in quadrant (I). Quadrant (IV) represents the cumulative causation relationship between population density and expenditure. Industry locates where the market is largest and the market is largest where manufacturing and manufacturing labour is located. This represents the Heckscher-Ohlin theme of comparative advantage, and demand. The inverse relationship between economies of scale and the relative concentration ration is found in quadrant (II). This characterises the authors' new trade theory and economic geography finding of a negative relationship between unexploited economies of scale and manufacturing concentration. The higher the unexploited economies of scale the more dispersed an industry will be. Finally, quadrant (III) illustrates the reduction in unexploited economies of scale and the quantity of manufacturing labour. There is a negative relationship between unexploited economies of scale and the level of manufacturing employment. Reductions in unexploited economies of scale are realized by expanding employment and output.

The empirical results of the model indicate low relative concentration, s_0, for industries with high levels of unexploited economies of scale, es_0, in areas with low expenditure, exp_0, and a small manufacturing labour force, l_0. This situation is represented by the rectangle *ABCD*. With the reduction of trade barriers, industries specialising in labour intensive products will become relatively concentrated in areas with an abundance of labour and a high localisation of expenditures. Increased competition in the centre reduces unexploited economies of scale and increases the elasticity of demand. This development is shown by triangle *EFGH*. These findings are supported by Brülhart and Torstensson (1996) whose model shows the inverse relationship between the levels of economies of scale and the elasticity of demand.

Absolute Concentration

To explain the cross-sectoral variation in *absolute* concentration in industry i, the empirical model was modified to the form;

$$S_i^A = \alpha + \beta_1 EXPEN_i^A + \beta_2 SCEC_i + \beta_3 IO_i + \beta_4 NTB_i \tag{2.10}$$

The independent variables in this specification are the same as in equation (2.9) except for the construction of the expenditure variable $EXPEN_i^A$ that is now measured in absolute terms instead of relative terms. The most promising estimated results of equation (2.10) were the log-transformed 2SLS-estimation. The estimated equation for 1992 is given as equation (2.10a), and for 1985 as equation (2.10b).

$$S_i^A = \underset{(3.059)}{0.7428} + \underset{(11.697)}{1.3966}.EXPEN_i^A - \underset{(2.699)}{0.0521}.SCEC_i + \underset{(2.244)}{0.0285}.IO_i + \underset{(2.111)}{40.0437}.NTB_i \tag{2.10a}$$

$$R^2 = 0.81 \quad \bar{R}^2 = 0.79 \quad n = 35 \quad df = 30$$

and for 1985

$$S_i^A = \underset{(3.292)}{1.1596} + \underset{(9.514)}{1.5431}.EXPEN_i^A - \underset{(0.353)}{0.0245}.SCEC_i + \underset{(1.894)}{0.0303}IO_i + \underset{(0.793)}{0.0203}.NTB_i \tag{2.10b}$$

$$R^2 = 0.73 \quad \bar{R}^2 = 0.69 \quad n = 35 \quad df = 30$$

The estimated equations show that a change in economic structure has occurred between 1985 and 1992. The 1985 estimate indicates that non-tariff barrier, and economies of scale were not significant. The latter coefficient also has the wrong sign. The estimated equation for 1992 shows significant results. The estimated coefficients are all significant. The constant term and expenditure coefficients are significant at the 1% level, while the remaining coefficients are significant at the 5% level. The economy of scale variable again has the wrong sign.

The authors provide an explanation for the divergence of this empirical result from their theory, but also point out that their results may be consistent with the theoretical literature. First, there exists a possible measurement error. The argument is made that the 1980s data used to measure economies of scale have become outdated and may not reflect the changes in technology and production techniques. Secondly, the authors point out that their economy of scale measurement is defined as 'the elasticity of average costs with regard to output.' If an industry produces a level of output on the high portion of its average cost curve, the industry would be characterised by 'unexploited scale properties'. Should this be the case, then their model indicates that an industry will be less concentrated the higher the level of unexploited economies of scale. The negative sign of the coefficient would then be acceptable.

Third, the authors introduce the work of Amiti (1998) who argues that in a world of imperfect competition there is an interaction between demand elasticities and trade costs. This presents two opposing forces. Industries whose products face a high elasticity of demand (and low scale economies) will be attracted to the larger market to avoid the extra burden of trade costs. On the other hand, an industry may be attracted to the smaller market due to relatively lower factor prices and production costs. In this case, firms with unexploited economies of scale may locate in the smaller market if trade costs are very low. The authors conclude that this theory would be consistent with their estimated results of the economies of scale variable.

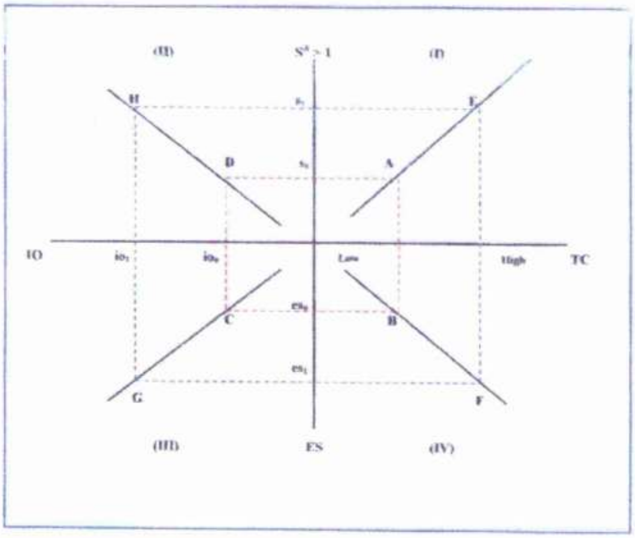
The results would also be consistent with the theory presented by Brülhart and Torstensson (1996). Industries with a low elasticity of demand and a high degree of unexploited economies of scale would tend to relocate away from the core as trade costs are reduced. In Figure 2.6, these types of industries would fall in the range *AE* in quadrant (I). It remains unclear why the authors did not estimate their model with a re-specification of the economies of scale variable. Amiti (1997), and Brülhart and Torstensson (1996) have suggested average firm size as a proxy for economies of scale.

The Model

The Haaland *et al.* (1999) model is graphed in Figure 2.6. The authors found a strong positive correlation to exist between absolute concentration, S^{a}, and the localisation of expenditures, $EXPEN^{a}$. The model is distinguished from the relative concentration model by the empirical significance of the input-output, IO_i, and the non-tariff barrier, NTB_i, variables. The empirical evidence supports the theory that industries that are dependent on input-output linkages, will tend to cluster. High trade costs can be reduced through industrial agglomeration. The force driving this agglomeration is the pecuniary advantage of external economies of scale provided by strong input-output linkages. The empirical evidence supports the theory that industries that are dependent on input-output linkages, will tend to cluster. High trade costs can be reduced through industrial agglomeration. The force driving this agglomeration is the pecuniary advantage of external economies of scale provided by strong input-output linkages.

In Figure 2.6, the rectangle *EFGH* shows that in the face of high trade costs, industries will agglomerate in the core. These industries have a low level of unexploited economies of scale and are dependent on strong input-output structures for external economies of scale. Industries with low trade costs and high-unexploited economies of scale are less dependent on strong input-output structures and will show a lower level of absolute concentration. These industries will be dispersed away from the core. This situation is shown by rectangle *ABCD* in Figure 2.6.

FIGURE 2.6
ABSOLUTE CONCENTRATION



Source: Author's diagram based on the work of Haaland *et al.*, (1999)

Strong input-output linkages are characteristic of absolute concentration in the core. In a market characterised by imperfect competition and economies of scale, product differentiation creates high demand elasticities and low levels of unexploited economies of scale. Industries located in the core are dependent on input-output structures to internalise the pecuniary advantages of external economies of scale. On the other hand, industries with trade costs, low demand elasticities and high levels of unexploited economies of scale are less dependent on strong input-output structures and will exhibit a lower level of absolute concentration.

Conclusions

The authors, Haaland *et al.* (1999), conclude that localisation of expenditure is the most important determining variable on industrial concentration, and has become more important because of economic integration be it relative- or absolute. The empirical results indicate that the measure of relative industry concentration supports the traditional theory of comparative advantage. The measure of absolute industry concentration supports the determining forces of both the new trade theory and economic geography. The model has indicated that the expenditure variable is significant thereby providing evidence for the role of the 'home-market'. The economic geography forces of industry localisation are supported by the positive influence of input-output structures and trade cost reductions contribution to agglomeration. The measurement of economies of scale issue remains open for future research. However, the theoretical reasoning surrounding the empirical results of this variable are supported by the model of Brülhart and Torstensson (1996).

2.2.7 Industry Characteristics, Comparative Advantage, and Industry Concentration

The research of Haaland *et al.* (1999) revealed that relative industry concentration resulted from traditional Heckscher-Ohlin comparative advantage. Absolute industry concentration was determined by pecuniary agglomerative forces arising from strong input-output linkages and high trade costs, as predicted by the new economic geography trade theory. Forslid, Haaland, and Midelfart-Knarvik (1999) continue this line of research. The author's objective is to twofold. First, to identify individual industry characteristics that determine their concentration. Concentration occurs because of: one, strong intra-industry linkages and increasing returns to scale, and, two, comparative advantage and the need to specialise. Second, to examine whether the reduction in trade barriers through economic integration has resulted in an increased level of overall industry concentration.

Forslid *et al.*, (1999) argue that industrial agglomeration is the result of 'self-reinforcing backward and forward linkages…[that result] from a combination of increasing returns to scale, trade costs, and the fact that firms are linked via their input-output matrices.' Intra-industry linkages consist of the dependencies between upstream (supplier) and downstream (final goods) industries that provide pecuniary externalities or external economies of scale. The dependencies embody the forward and backward linkages that form the input-output structures between industries. The forward linkage is the supply relationship from intermediate supplier industries to final goods producing industries. The backward link is demand by final goods-producers for intermediate inputs from supplier industries. This intra-industry dependency forms the basis for agglomeration forces in markets characterised by imperfect competition and economies of scale. The consequence of trade barrier reductions is a possible relocation of both upstream and downstream industries to areas with initial levels of industry concentration (Krugman and Venables, 1996).

Forslid *et al.*, (1999) recognise the existence of two conflicting economic forces in pre-integrated Europe. The first is the desire to reap the pecuniary benefits of agglomeration. The second is the market segmentation effect of high trade costs resulting in high product prices and excess production capacity. In a pre-integrated Europe, industries developed in segmented markets. High trade barriers and domestic market paucity resulted in unexploited economies of scale. Upstream and downstream industries were geographically separated with high intra-industry trade costs. Nerb (1988) has itemised the trade barriers as; 'administrative barriers (customs), frontier delays and costs, differences in VAT and excise taxes, standards and regulations, transport market regulations, public purchase of goods, implementation of EC law, capital market restrictions and other barriers.' In their study, Forslid *et al.*, (1999) consider three types of trade costs 'transport costs, tariffs, and export taxes' in their simulation model. The authors note that high trade costs make it less attractive to export products. This view is supported by an EC survey, which finds that high distribution and import costs dampen export incentives. Barriers to trade work in the direction of less concentration.

The authors theorise that with high trade costs, firms are locked in geographic space. Trade cost reductions create an incentive for firms to relocate. Relocation of particular firms in different industry sectors occurs for a number of reasons; the desire to exploit internal economies of scale, the need for strong input-output linkages to reap external economies of scale, the need to eliminate decreasing returns to scale, and the desire to specialise in production through the forces of comparative advantage. As trade costs are reduced, individual firms in different industrial sectors respond for their own reasons by either agglomerating in the centre or relocating away from the centre depending on the required levels of economies of scale. Forslid *et al.*, (1999) theorise that as trade costs come down, some industries will locate to the centre, and as trade costs continue to decline, other industries may relocate away from the centre.

Industry Concentration Measurement

Forslid *et al.* (1999) develop a 'summary index' of concentration in order to study the effects of greater integration on agglomeration tendencies in *specific* industries. To this end, they construct a statistic to measure the value of absolute industrial concentration for an individual industry *i*.

$$C_i = \sqrt{\sum_j \left(s_{ij} - \bar{s}_{ij}\right)^2 / N} \qquad (2.11)$$

where $s_{ij} = X_{ij} / \sum_j X_{ij}$ represents the value of the share of 'production in industry *i* taking place in region *j*, with *N* representing the number of regions (4) in Europe.' The statistic $\bar{s}_{ij}$ is the average value of s_{ij}, so that the measure of absolute concentration C_i is the standard deviation of the distribution of s_{ij} where $s_{ij} < 1$. A high value of this statistical measure, $C_i > 1$, means a high concentration of industry *i*.

The industry concentration measure of Forslid *et al.* (1999) is different from Amiti's (1997) relative concentration S_i^R measure in equation (2.7). The difference is found in the fact that Amiti (1997) relates a country's share of production in industry *i* to the country's share of production in total production. These country shares can vary in value size and are thus not constant. Forslid *et al.* (1999) relate the regional share of production in industry *i* to the industry's average industry share of the regions. Since the sum of the industry share per region must equal to one, the average industry share value for all industries across all the regions will be the same, i.e. a constant value. The concentration measure is not related to country size.

The absolute concentration coefficient, C_i, proposed by Forslid *et al.* (1999), is more akin to Amiti's (1997) formulation of the absolute concentration coefficient. Both authors use a country's regional share of industry *i's* production (employment) as a variable in their calculation, s_{ij}. The Forslid *et al.* (1999) method adjusts the calculation with a constant value across all regions. Their method calculates the concentration measure for each industry as a deviation from a constant average so that each industry's measure is a relative deviation from an industry's national mean. Since the mean values are all identical, the industry concentration measures are individual standard deviations from a constant mean value.

The significant difference between the concentration measure of Forslid *et al.* (1999) and that of Amiti (1997) is that the Forslid *et al.* (1999) model uses one measurement to capture the three forces determining industry concentration. The initial location of industry clusters, the relative requirements of comparative advantage, economies of scale, and intra-industry linkages in the face of declining trade costs determine the degree of industry concentration. The inverse relationship between economies of scale and demand elasticity is also true for this model.

Empirical Estimations

The simulations[17] of Forslid *et al.* (1999) reveal two major results with respect to changes in patterns of production and location for two industrial sectors. The first group consists of the industrial sectors: chemicals, machinery, transport equipment, and metals, which are strongly dependent on economies of scale and intra-industry linkages. The second group is comprised of: wood products, food products, textiles, and leather products. This latter cluster of industries appears to be predominantly dependent on the forces of comparative advantage and specialisation. The relevant statistics for these two groups of industries are presented in Appendix 2C, Chapter 2, Table 2C.1.

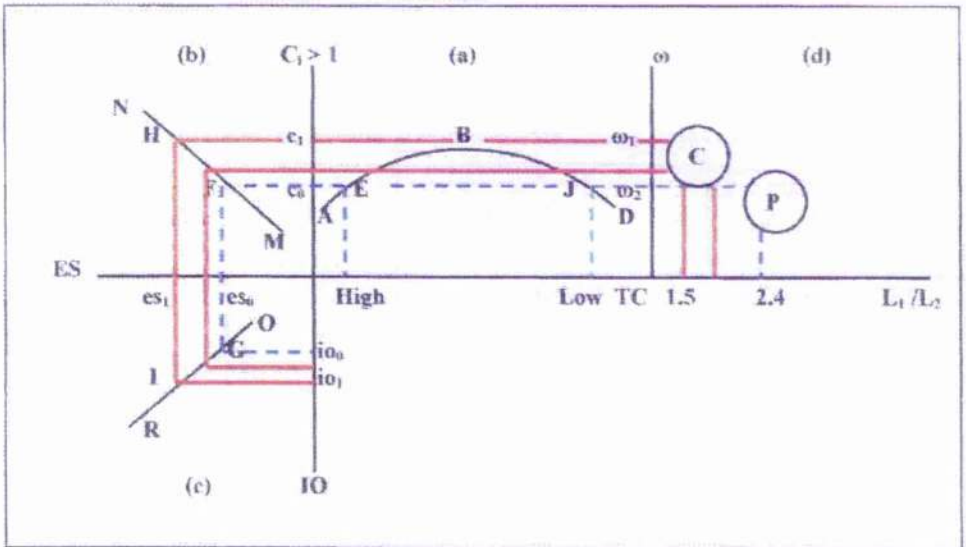
The simulation results for the first group of industries indicate that the levels of regional production activity remain relatively constant as trade costs are reduced. This suggests a stable polycentric production structure. The forces behind this 'strong agglomeration tendency' in large markets is the dependence of these industries on high levels of increasing returns to scale, and the need for strong input-output linkages. For example, the chemical industry shows the need for high (above average) levels of returns to scale, above average levels of input shares from its and other intermediate industries, and a need for skilled labour. The data indicates that the chemical, machinery, transport, and metal industries all have high scale elasticities, show varying dependencies on input-output structures, and are dependent on a skilled labour force.

The transport and metals industries show an above average need for both unskilled and skilled labour. The simulation results indicate that a reduction in trade costs will cause these industries to increase their concentration in the core, increasing the relative wages rates in these regions. The authors find that as trade costs are further reduced, general equilibrium effects of relative factor price increases

[17] Forslid *et al.*, (1999), have used a geographic cluster of national administrative regions, which include the non-EU countries of Switzerland, Iceland, and Norway. Excluding these regions the European North consists of Finland, Sweden, (Iceland and

will result in those industries dependent on unskilled labour to relocate to peripheral regions for comparative advantage. The metal industry is a case in point, with a relatively lower return to scale elasticity, and a relatively higher dependence on unskilled labour. Although the data does not show a strict one-to-one relationship between the variables, the general results of the economic forces driving the behaviour of these industries in the simulation analysis are captured in Figure 2.7.

FIGURE 2.7
CHEMICAL, MACHINERY, TRANSPORT EQUIPMENT, AND METAL INDUSTRIES



Source: Author's diagram based on the simulation model of Forslid *et al.*, (1999)

The inverted U-curve showing the quadratic relationship *ABD* between absolute concentration C_i and high, intermediate, and low trade costs are presented in panel (a). This represents the new geography theme of international trade. The positive relationship *NM* between the need for high levels of economies of scale and the tendency to concentrate in the centre is presented in panel (b). The line *OR*, in panel (c) illustrates the positive relationship between the need for high levels of internal returns to scale, and the strong need for input-output structures. The new trade theory of imperfect competition and economies of scale is captured by the relationships in panels (b) and (c). Finally, the traditional Heckscher-Ohlin theory of competitive advantage through relative resource abundance is shown in panel (d). There exists an inverse relationship between relative wages and the relative supply of unskilled to skilled labour ratio. Relative wages are higher in the core (*C*), and lower in the periphery (*P*).

At initial relatively high concentration levels, c_0, and high trade costs, specific industries requiring high levels of economies of scale, intra-industry linkages, and unskilled / skilled labour are located at point *E* on the outer limit of the centre regions. As trade costs decline, existing firms and new

Norway); the EU South consists of Greece, Italy, Portugal, and Spain; the EU West is Belgium, the Netherlands, Ireland, France, and the UK; and Central Europe consists of Austria, Denmark, and Germany (Switzerland).

entrants into the industry will agglomerate in the centre to exploit internal returns to scale es_1, and strengthen their input-output relationship to io_1. The effects of agglomeration raise relative wages in the centre regions to ω_1. There is a range of intermediate costs that retains industries in the centre regions. The authors have found that as trade costs decline further, some industries such as metals, will relocate away from the core to the periphery. These industries are characterised by lower internal economies of scale, but dependent on a relatively higher unskilled to skilled labour ratio. At low levels of trade costs, J, industries are driven by comparative advantage to regions with an abundance of unskilled labour and lower relative wages, ω_2, thereby reducing geographical concentration.

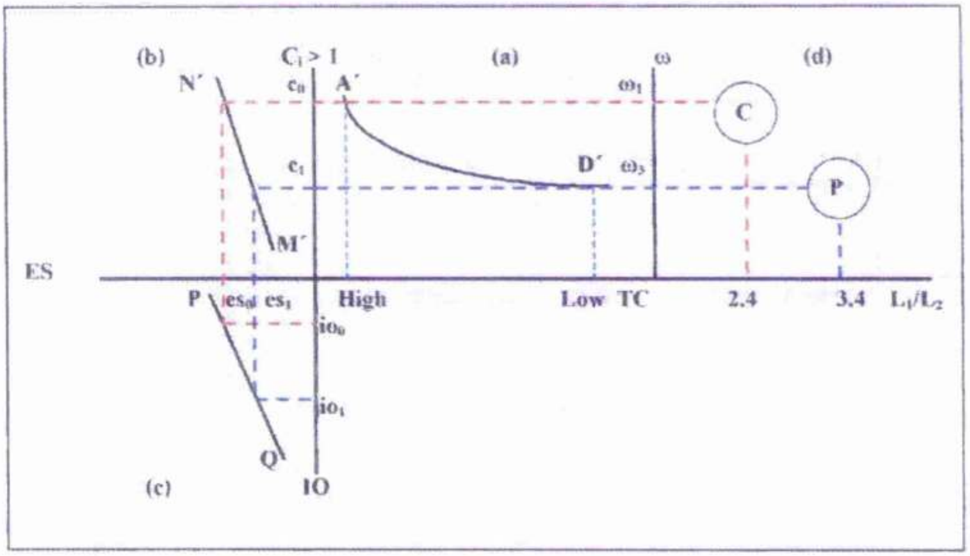
These simulated results appear to contradict the finding of Brülhart and Torstensson (1996) who find the opposite results. These authors conclude that a reduction in trade costs will cause industries requiring high levels of economies of scale to increase their concentration in central countries. This point of view also finds support in the work of Haaland *et al.* (1999, p.8). The authors theorise, supported by empirical estimates, that '…even though degree of scale economics have an ambiguous impact on *relative* concentration, it does suggest that industries characterised by significant economies of scale will be *absolutely* more concentrated than others'. The seeming contradiction is due to the absence of relative factor price effects in their respective models.

The second industry cluster consists of wood products, food products, textiles, and leather. The simulation shows that these industries will undergo a changing pattern of production as trade costs are lowered. These industries are characterised by low levels of economies of scale, a relatively high level of intermediate inputs, and a strong dependence on unskilled labour. The authors find that with low trade costs these industries will relocate from initial high concentrations in the centre and become increasingly more concentrated in the periphery. The removal of impediments to trade will cause these industries to relocate and concentrate to take advantage of strong 'intra-industry linkages' and regions with an abundance of low cost unskilled labour to realise their competitive advantage position. The dynamics of the economic forces for these industries is shown in Figure 2.8.

The line $A'D'$ in panel (a) represents the negative relationship between absolute industry concentration C_i and trade cost reductions. In panel (b) the line NM' is relatively inelastic since these industries have low economies of scale elasticities. The data reveals a negative relationship between economies of scale of input-output structures. The line PQ in panel (c) expresses this relationship. The relative wage and labour ratios are shown in panel (d).

At high levels of trade costs, these industries are concentrated in the core at c_0, facing a high relative wage ratio, ω_1. The low level of economies of scale and input-output structures are shown respectively by es_0 and io_0. As trade costs are reduced, these industries will relocate away from the core to the periphery because of their need for relatively high levels of input-output structures and large quantities of unskilled labour. These industries are relatively labour intensive.

FIGURE 2.8
WOOD, FOOD, TEXTILES, AND LEATHER INDUSTRIES



Source: Author's diagram based on the simulation analysis of Forslid *et al*., (1999)

The production of textiles is expected to relocate from Austria, Denmark, and Germany, to the EU West, but especially to Greece, Italy, Portugal, and Spain. These countries are characterised by strong intra-industry linkages, and low labour costs. The leather industry is also expected to agglomerate in the aforementioned southern EU countries, due to their comparative advantage in labour-intensive production. The loss of Government subsidies in the North will cause the wood products sector to relocate throughout the other EU regions. The authors are of the opinion that manufacturing industries with high levels of economies of scale have reached their concentration peak. Industries, requiring low levels of economies of scale, and dependent on comparative advantage, will continue to relocate and cluster as trade cost are further reduced.

The Overall Concentration Measurement

As a final exercise, Forslid *et al.* (1999) attempt to answer the Krugman and Venables (1995) question of whether, 'All manufacturing activities [will] tend to concentrate in the core, with de-industrialisation of the periphery?'[18] To answer this question, Forslid constructs an 'overall' industrial concentration' index.

$$H = \sqrt{\Sigma_j (h_j - \bar{h}_j)^2 / N} \qquad (2.12)$$

[18] *Ibid.* p. 18

where, $h_j = \sum_i X_{i,j} / \sum_j \sum_i X_{i,j}$ is the share of total manufacturing production in region j, with N representing the (4) geographic clusters of national regions in Europe. A value of $H > 1$ indicates a high level of industry concentration. A comparison of the values of this coefficient for two different time periods will indicate whether increased concentration has occurred. As argued above, to determine whether country j, either a core, and / or periphery country has experienced an increase or decrease in industry concentration, we would have to examine the individual values of the country's squared deviation from the mean.

Simulation Model Conclusions

The simulation results per sector show that, for intermediate trade costs, agglomeration forces dominate, although the 'trade off between inter-industry linkages and general equilibrium factor price effects' will determine the region in which this occurs. For low trade costs, the forces of comparative advantage dominate. When considering the simulation results of general equilibrium effects, Forslid *et al.* (1999) conclude that further economic integration may not necessarily result in increased industrial concentration to the extent that peripheral regions would suffer a decline in welfare. 'On the contrary, when we are close to free trade, all regions, apart from Europe Central, gain from further integration in our simulations.'[19] The results of Forslid *et al.* (1999) simulation sustain the view of multi-agglomerate production structures.

2.2.8 Economic Geography and Regional Production Structure: An Empirical Investigation

Davis and Weinstein (1998) empirically assess the concept of the 'home market effect' (Krugman, 1980). The home market effect distinguishes the Heckscher-Ohlin comparative advantage trade model from that of the new economic geography model. They pose the question, 'Can unusually strong demand for a good in a country lead that country to export the good?' In a comparative advantage model the answer would be negative, but in an economic geography model, with economies of scale and trade costs, the answer would positive.

The authors build on the assumptions of the Krugman (1980) and observe that with incomplete specialisation both countries have identical demand patterns and produce the same number of varieties resulting a zero trade balance. The author note that the Krugman (1980) model suggests 'that the predictions of the production structure, *ceteris paribus'* should be centred around an even distribution of the industries across countries.' Any deviations from this evenly distributed production structure must then be explained by idiosyncratic demand. Idiosyncratic demand measures 'the extent to which the relative demand for a good within an industry differs from that of the rest of the world.' The authors wish

[19] *Ibid.* p. 23

to identify the components of this idiosyncratic demand, which has a *magnifying* effect on production thereby causing production structures to diverge.

To test the existence of the home market effect the authors develop a measure of 'unusual strong demand' for output of an industry called idiosyncratic demand, and combine this with a gravity measure to 'derive industry specific parameters on the dissipation of demand across space.' This construct allows for the inclusion of demand in other geographic regions, and is thus an indicator of 'market access.' This introduces the cross-country effects of demand.

Methodology

Davis and Weinstein (1998) consider three levels of product aggregation: varieties, goods, and industries. Product *variety* is inherent to the economic geography model where economies of scale are important. A *good* is defined as ' a collection of a large number of varieties produced under monopolistic competition.' Goods exhibit increasing returns to scale in production. At the goods level the authors make a distinction between the Heckscher-Ohlin comparative advantage model, and the economic geography model. In the former, a good is theorised as being a homogenous product, while in the latter it is a heterogeneous product. Finally, an *industry* 'consists of a collection of goods produced using a common technology.' This definition of industry is similar for both the comparative advantage model and the increasing returns model. In the Heckscher-Ohlin model the collection of industry goods are Leontief input coefficients, while in the economic geography model 'all varieties of all goods within an industry use inputs in fixed proportions.'[20]

The authors develop the following model for their empirical analysis, where n is an index of industries, g is an index of goods, and c is an index of countries. The symbol W stands for the world with ROW referring to the rest of the world (excluding country c). The total output of good g for industry n in country c is represented by X_g^{nc}, and that for the rest of the world by X_g^{nROW}. The vector of endowments for country c is represented by V^c. The symbol Ω is the inverse of the technology matrix, and Ω_g^n is the row corresponding to the g' th good in industry n. These symbols provide the basic elements to construct the Heckscher-Ohlin model of goods production that determines the structure of industry in a country. This model is defined as:

$$X_g^{nc} = \Omega_g^n V^C \qquad (2.13)$$

[20] Empirically, industry is defined as 3 digit ISIC data, while goods are defined 4 digit ISIC data.

The authors define, $\tilde{\Omega}_n$ as 'the n'th row of an inverse technology matrix for industry output where the coefficients indicate average inputs at the equilibrium scale per variety…[and]…G^n as the number of products in industry n.' The output of industry n in country c is defined as:

$$X^{nc} = \sum_{g=1}^{G_n} X_g^{nc} = \overline{\Omega}^n V^C \qquad (2.14)$$

The authors assume a 'square' Heckscher-Ohlin model for all countries with identical Leontief production technologies (equation 2.13). This model determines a country's industrial structure and production, but reveals nothing about the composition of production 'across the goods within an industry' (equation 2.14). The authors conclude that within a country, resource constraints become specific to each industry, because of the assumption that all varieties are produced with an identical factor input mix, and the Leontief assumption of identical production technologies. Since resources are allocated in the same proportion across the goods of all industries, domestic demand is such, that each country produces 'base level' of goods in a particular industry. Idiosyncratic demand for a country's products will cause output to exceed this 'base level' of goods, and gives rise to Krugman's (1980) home market effects. It is this demand that results in Krugman's intra-industry specialisation.

To develop an equation capturing both these demand components, Davis and Weinstein (1998) define the following terms; D_g^{nc} represents a variable that defines the demand within a country for a product produced in many domestic locations; $\tilde{D}_g^{nc}$ is a variable defining domestic derived demand that producers in different locations[21] face for their product; and, $\tilde{D}_g^{nROW}$ defines the foreign derived demand. An output share is defined as; $\gamma_g^{nc} = \frac{X_g^{nc}}{X^{nc}}$ and represents the share of industry g's output in the total domestic output of industry n. A demand share is defined as; $\tilde{\delta}_g^{nc} = \frac{\tilde{D}_g^{nc}}{\tilde{D}^{nc}}$, and represents derived domestic

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[21] The gravity model is embedded in the variable $\tilde{D}_g^{nc}$. The gravity model at the industry level is specified as:

$$\ln\left(T_{cc'}^{n}\right) = \phi + \lambda \ln\left(GNP_c GNP_{c'}\right) + \psi \ln\left(DIST_{cc'}\right) + \eta_{cc'}^{n}$$

where $T_{cc'}^{n}$ is the volume of trade in industry n between countries c and c', GNP_c is the GNP of country c, $DIST_{cc'}$ is the distance between c and c'. The parameters to be estimated are ϕ, λ, ψ, and η, where η is normally distributed error term. The authors use the estimated coefficient on the distance variable that measures 'the degree to which distance causes the demand for a product to decline.' Then derived demand for local production is defined by, $\tilde{D}_g^{nc} = k_g^n \sum_{c'} D_g^{nc'} DIST_{cc'}^{\psi_n}$ and world demand given by $\tilde{D}_g^{nW} = k_g^n \sum_{cc'} D_g^{nc} DIST_{cc'}^{\psi_n}$. To take foreign demand into consideration so that 'redistribution of world demand does not change aggregate world demand, the authors require that,' $k_g^n = \sum_c D_g^{nc} \Big/ \sum_{c,c'} D_g^{nc} DIST_{cc'}^{\psi_n}$.

demand for good g as a share of total derived demand for the goods produced by industry n. The authors define $SHARE_g^{nc} \equiv \gamma_g^{nc} X^{nc}$, which represents the 'country's base level of production for each good in an industry…[and]… $IDEODEM_g^{nc} \equiv \left(\widetilde{\delta}_g^{nc} - \widetilde{\delta}_g^{nROW}\right)X^{nc}$, which measures 'the extent of idiosyncratic derived demand.'

The demand for a good g from industry n in country c is specified as follows:

$$X_g^{nc} = \alpha_g^n + \beta_1 SHARE_g^{nc} + \beta_2 IDEODEM_g^{nc} + \in_g^{nc} \tag{2.15}$$

where the variable *IDEODEM* measures 'the extent to which the relative demand for a good within an industry differs from that in the rest of the world.

Davis and Weinstein (1998) postulate, that if endowments matter at the four-digit goods level, then the Heckscher-Ohlin comparative advantage model of goods production can be inserted in equation (2.15) as follows:

$$X_g^{nc} = \alpha_g^n + \beta_1 \gamma_g^{nROW} X^{nc} + \beta_2 (\widetilde{\delta}_g^{nc} - \widetilde{\delta}_g^{nROW}) X^{nc} + \Omega_g^n V^c + \in_g^{nc} \tag{2.16}$$

or

$$X_g^{nc} = \alpha_g^n + \beta_1 SHARE_g^{nc} + \beta_2 IDEODEM_g^{nc} + \Omega_g^n V^c + \in_g^{nc} \tag{2.16a}$$

The estimate of β_2 allows the authors to distinguish between three hypotheses. One, 'in a frictionless world (comparative advantage or increasing returns), the location of demand does not matter for the pattern of production, so we would predict $\beta_2 = 0$…[two]…when there are frictions to trade, demand and production are correlated even in a world of comparative advantage, reaching exactly one-for-one when the frictions force autarky. However, production does not rise in a more than one-for-one manner. Accordingly, if we find $\beta_2 \in [0,1]$, we conclude that we are in a world of comparative advantage with transport costs. Finally, in the world of economic geography, we do expect the more than one-for-one response, hence $\beta_2 > 1$.'[22]

Outcomes

First, the estimated gravity equation showed positive results. The coefficients had the expected signs and were significant for all industries. The distance coefficient was negative and significant. A one percent increase in distance reduced trade by one percent.

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[22] Davis and Weinstein (1998), *Op. Cit.*, p.18

Second, the estimated distance coefficient was used to develop a new measure of idiosyncratic demand. The authors found 'that accounting for geography causes large changes in the demand deviation variable for small countries[23] far more frequently than for large countries.' This leads them to conclude that it is more important for small economies to be located near large markets than larger economies.

Third, equation (2.16) was estimated using four-digit data. The results revealed an estimated coefficient value on the IDEODEM variable that exceeded unity, indicating the presence of a home market effect. The authors found that if the 'derived demand deviation rises by 1 percent, then output rises by 1.6 percent.' They conclude that production in home markets responds by more than a one-for-one factor to idiosyncratic demand.

Fourth, when estimating the effects of derived demand deviation for each individual four-digit sector, Davis and Weinstein (1998) found that 'half of the sectors had coefficients on IDEODEM that are larger than unity, and of these eleven are significantly greater than unity.' This result suggests that some industries have constant returns to scale while others have increasing returns proving the presence of the home market effect.

Fifth, the industry-pooled estimation[24] revealed that more 'than half of the industries exhibited home market effects' with four of the estimated coefficients being significantly larger than unity. Furthermore, for fifty percent of the *sectors* within these industries the coefficient on IDEODEM exceeds unity. Davis and Weinstein (1998) are led to accept the theory of economic geography, since the evidence shows that most of the sectors[25] exhibit home market effects.

Sixth, the authors provide a summary on the importance of economic geography in OECD production. They examine the 'relative sizes of the sectors for which β_2 is greater than unity.' At the four-digit product level of 50 sectors, the sectors with IDEODEM estimates greater than unity, 'account for 64% of total output.' At the three-digit industry level that encompasses all manufacturing output in 22 countries, '50% of all manufacturing production is governed by economic geography.'

Davis and Weinstein (1998) conclude that 'sectors that appear to have home market effects account for a majority of manufacturing output....[and]...economic geography matters for international specialisation.'[26] They also conclude that 'comparative advantage matters....[since]...one-third to one-half of OECD manufacturing output seems to be governed by simple comparative advantage. However, increasing returns also play a vital role in the particular form known as economic geography.'[27]

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[23] There are twenty-two countries in the data set. Australia, Belgium/Luxembourg, Canada, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Sweden, UK and US. These thirteen countries provided data at the three and four-digit level. The remaining nine countries provided data at the three-digit level. These were: Austria, Denmark, Greece, Ireland, New Zeeland, Portugal, Spain, Turkey, and Yugoslavia.

[24] The four-digit data was pooled with each three digit-industry, with the coefficient on IDEODEM being allowed to vary across three-digit industries.

[25] The sectors were: radio, television and communication equipment, electrical appliances and house-wares, and motor vehicles.

[26] Davis and Weinstein (1998), *OP. Cit.*, p.36

[27] *Ibid*, p.38

In a companion paper, Davis and Weinstein (1999), use a compacter version of their model to examine the production structure across regions within a country. The model does not include the gravity equation. They postulate that economic geography could be very important for the production structure across regions due to the lower interregional trade costs, and the high degree of interregional factor mobility within a country. The authors theorise that a country may have a diversified regional production structure in the absence of trade costs with only interregional transport costs. Larger regions are attractive for industry location because of demand and supply linkages, as well as pecuniary agglomeration advantage. Wages are higher and prices lower in these regions making them attractive for labour migration at the expense of the 'hinterland'.

Davis and Weinstein (1999) applied their model to a sample of regions in Japan to examine the importance of economic geography in determining regional production structures. The empirical evidence revealed that in sectors using low-skilled labour, there was no evidence of economic geography effects. However, economic geography effects were significantly present in the sectors using high-skilled labour.

The analysis revealed mixed results with the respect to the estimated coefficients[28] on IDEODEM. Of the nineteen industries, six showed a negative coefficient ($\beta_2 < 1$). The six industries are: apparel, furniture, petrol and coal products, stone, clay and glass, fabricated metal, and general machinery. Of these six, the estimated negative coefficients for two only industries – apparel and furniture – are significant at the five percent level. The remaining four estimates are insignificant. Four industries – printing, rubber, leather and leather products, and other manufacturing – revealed estimates for $\beta_2 \in [0,1]$. Only the estimate for the printing industry was significant at the five percent level supporting the hypothesis of comparative advantage with transport costs for the industry.

Economic geography was revealed to be statistically significant for nine of the nineteen manufacturing sectors. The eight sectors that showed a $\beta_2 > 1$ are: 'lumber, transportation equipment, iron and steel, electrical machinery, chemicals, precision instruments, nonferrous metals, textiles, and paper and pulp.' It must me noted that the estimate for lumber ($\beta_2 = 1.0622$) was marginally larger than unity. The empirical results support the presence and importance of home market effect for these industries. They locate in large regions and are dependent on increasing returns to scale.

The authors provide two reasons for the strength of economic geography at the regional level. One, lower trade costs within a country means 'lower implicit protection for production in the relatively smaller markets.' Two, the high factor mobility within a country 'reinforces the economic geography effects, relieving scarcities in regions favourable on economic geography grounds for production of particular goods.' The authors conclude by pointing out that if international trade costs are reduced to the level of interregional trade costs, 'then quite a substantial international restructuring of industry may be in the offing.'

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[28] Davis and Weinstein (1999), Table 6, p. 400. The authors used three-digit industry data for 19 industries across 47 prefectures.

2.2.9 Location of European Industry

The objective of the study by Midelfart *et.al.*, (2000), is to study the changes in industry location in Europe between the years 1970 and 1997. To this end, the authors use a number of statistical methods to assess the changes in industry location. First, the Krugman (1991a) industry index is used to determine whether the economic structures between countries have become more similar or less similar. Second, they develop an Industry Characteristic Bias (*ICB*) measurement to determine in what type of industries countries are specialising. Third, the 'location Gini' coefficient is employed to examine which industries are becoming more concentrated. The authors also develop a Country Characteristic Bias (*CCB*) measurement to determine whether 'particular types of industries are concentrated in particular types of countries.' Fourth, the study seeks to identify the underlying forces that determine industry location patterns. To this end, the authors specify a regression model wherein industry and country characteristics are allowed to interact in order to measure and explain these industry location patterns. All measurements are at the EU country level. The sample consisted of fourteen EU countries. Luxembourg was excluded from the analysis.

Industry Index

The industry index measurement allowed the authors to address and answer two questions: How specialised are countries? How similar are the industrial structures of different countries?

To answer the first question, Midelfart *et.al.*, (2000), calculated four year country averages for 1970/73, 1980/83, 1988/91 and 1994/97, using the variable gross value of manufacturing output. The data revealed a decline in value for ten countries between 1970/73 and 1980/83, indicating that production locations became more similar. However, form 1980/83 the average values showed a rising trend, for all countries except the Netherlands, indicating greater divergence, and therefore an increase in specialisation. The authors consider two possible reasons for this divergence in production structures; one, high initial shares in an industry, and two, 'differential change.' A country with a high initial share in a given industry will show diverge if the industry is growing fast. Differential change refers to 'countries moving in and out of industries.' The authors estimate that more than 80% is due to differential change, and 20% due 'to amplification of initial differences.'

The answer to the second question is obtained by examining bilateral index values between countries. The authors found that 'of the 91 distinct pairs, 71 exhibit increasing difference between 1980/83 and 1994/97,' and conclude that, 'the vast majority of countries experienced a growing difference between their industrial structure and that of their EU partners.' This leads the authors to examine the characteristics of industries in different countries.

Industry Characteristic Bias (ICB)

The answer to the question, 'What are the characteristics of industries located in each country?' is found through the construction of the Industry Characteristic Bias measurement. This measurement identifies industry characteristics[29] and allows the authors to study how the characteristics in each country's industry structure have changed over time. The industry characteristic bias for each characteristic in country i is given by:

$$ICB_i(t) = \sum_k v_i^k(t) z^k \qquad (2.17)$$

where, v_i^k is the share of sector k in the total production activity of country i, and z^k the set of industry characteristics. The authors found 'the industrial structures of France, Germany, and Great Britain are characterised by high returns to scale, high technology, and a relatively high educated workforce. This is distinctly different from Greece, and Portugal, which are biased towards industries with low returns to scale, low technology and a workforce with relatively little education, that have a high final demand bias and a low share of non-manual workers...Portugal's and Greece's industrial compositions are significantly more similar to each other than they are to that of Spain,...and Spain has industry with higher returns to scale and higher technology than Portugal and Greece.[30]' The authors conclude that there exist significant cross-country differences of industry characteristics.

'Location Gini' Coefficient

Midelfart *et.al.* (2000), found a marginal decline in the concentration of the overall manufacturing sector. They reconcile this with their findings of greater country specialisation by noting that countries are not equal in size, and that individual industries have a much more varied development pattern than do countries. The authors group industries by their levels and changes in concentration. There are four main categories: a) concentrated industries that have remained concentrated over time (*CC*); b) concentrated industries that have become less concentrated (*CD*); 3) dispersed industries that have become more concentrated over time (*DC*); and, 4) dispersed industries that have stayed dispersed (*DD*). The remaining industries are classified as residual.

There are six concentrated (*CC*) industries: Motor Vehicles, Motor Cycles, Aircraft, Electrical Apparatus, Chemical Products NEC, and Petroleum Products. The six industries that were concentrated and have shown some dispersion (*CD*) are: Beverages, Tobacco, Office & Computing Machinery,

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[29] Industry characteristics examined: economies of scale, technology levels, R&D intensity, capital intensity, share of labour, skill intensity, higher skills intensity, intra-industry linkages, inter-industry linkages, final demand bias, sales to industry, and industrial growth. (Midelfart *et.al.*,2000), Box 2.2, p.13

[30] (Midelfart *et.al.*,2000), p.16

Machinery & Equipment, Radio-TV & Communication, and Professional Instruments. The dispersed industries that have become more concentrated (*DC*) are: Textiles, Wearing Apparel, Leather and Products, Furniture, and Transport Equipment NEC. Finally, the dispersed industries that have stayed dispersed (*DD*) are: Food, Wood Products, paper & products, Printing and Publishing, Metal Products, Non-Metallic Minerals NEC, and Shipbuilding.

Midelfart *et.al.* (2000), have examined the characteristics of concentrated and dispersed industries. The (*CC*) industries are characterised by: high increasing returns to scale, high/medium technology need, and high/medium final demand bias.[31] Three of the six industries – Motor Vehicles, Aircraft, Chemicals – use a 'high share of intermediates from their own sector, while most use little agricultural inputs.' The (*CD*) industries are characterised by 'lower increasing returns to scale, less reliant on intra-industry linkages, but slightly more reliant on inter-industry linkages, have a higher skill intensity, and less significant final demand bias.' These industries have experienced rapid growth in the last thirty years. The (*DC*) industries are characterised by 'low increasing returns to scale, low technology, a high share of agricultural inputs, and low skill intensity.' These industries have grown relatively slowly. Finally, the (*DD*) industries are low technology with all, except Transport Equipment, using high levels of agricultural inputs.

Country Characteristic Bias (CCB)

The country characteristic bias is a measure that examines the relationship between country characteristics and industry concentration. It provides an answer to the question: 'Are particular types of industries concentrated in particular types of countries?' The answer to this question contributes to the understanding of industry location. The measure is constructed as follows:

$$CCB^k(t) \equiv \sum_i s_i^k(t) z_i \qquad (2.18)$$

where, s_i^k is the share of country i in the total activity of industry k, and z_i refer to the country characteristics.[32] The measure CCB^k summarises the country characteristics for each industry.

The authors found, that industries that are characterised by 'high technology, high-medium returns to scale, and capital intensive, tend to locate in the core countries,' such as industries classified as (*CC*) and (*CD*). Industries that were initially dispersed, such as (*DC*) and (*DD*), showed a bias towards the periphery regions. The authors also found, that, 'over time, (*CC*) and (*CD*) industries have started to move out of the core,..[while]...dispersed industries (*DD*) and (*DC*), have moved toward locations with

[31] Percentage of sales to domestic consumers and exports.
[32] Country characteristics are the following: market potential, capital labour ration, average manufacturing wage, relative wages, researchers and scientists, education, agricultural production, regional aid, and total state aid (Midelfart *et.al.*,2000), Box 3.1, p.25

higher market potential.'[33] Similar results were found for the wage *CCB*. Wages are highly correlated with core countries. However, 'the country bias of low and medium return to scale industries….favoured the low wage economies rather than peripheral countries.'

When considering a country's endowment of researchers, the authors found a difference between the low-tech industries in the (*DC*) and (*DD*) groups. The (*DD*) industries showed a bias towards countries with an abundance of researchers, since these locations also provide access to natural resources. Finally, industries characterised by low and high capital labour ratios are 'biased towards similar locations, with high market potential, high wages, and a large number of researchers.' The authors conclude that 'capital intensity is not likely to be a driving force behind the choice of location' because of the high degree of capital mobility within the EU.

Spatial Separation Index

The spatial separation index is developed by Midelfart *et. al.*, (2000) to study the geographic distance between the concentration of individual industries and the countries in which they are located. The index is constructed as follows:

$$SP^k \equiv C\sum_i \sum_j (s_i^k s_j^k \delta_{ij}) \qquad (2.19)$$

'where, δ_{ij} is a measure of the distance between i and j, s_i^k is the share of industry k in location i, and C is a constant. For a given location i, $\sum_j (s_j^k \delta_{ij})$ is the average distance to other production in industry k. The first summation adds this over all locations i, weighted by their share in the industry, s_i^k. The interpretation of $\sum_i \sum_j (s_i^k s_j^k \delta_{ij})$ is therefore a production-weighted sum of all the bilateral distances between locations. This measure is zero if all production occurs in a single place, and *increases* the spatially separated is production.'[34]

Midelfart *et.al.*, (2000), found different concentration patterns over time, which are reflected in an inverse-U shape for manufacturing as a whole. Between 1970/73 and 1982/85, there was an increase in spatial separation that levelled out in the mid 1980s, and declined after EU economic integration. The spatial separation that occurred during the 1970 was 'of far greater magnitude than the clustering that took place in the 1990s.' Furthermore, 'the spatial distribution of European manufacturing appears to be largely driven by developments in Southern Europe (and possibly Ireland).' The authors found that EU manufacturing dispersed when the Southern European countries increased their manufacturing share

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[33] Midelfart *et.al.*, (2000), p.25.
[34] *Ibid*, p.28

between 1970/73 and 1982/85. This trend continued during the 1980s, but was reversed as the Southern European share in total EU manufacturing started to decline marginally. This contributed to the increase in spatial clustering in the 1990s.

The authors found some significant developments. First, the high tech industries that are the least separated throughout the entire time period, started to move out of central regions. The five high tech industries that moved out of the central regions and separated geographically were: Drugs and Medicines, Office and Computing, radio-TV and Communication, Electrical Apparatus NEC, and Professional Instruments. Aircraft moved to the core. These industries also became less geographically concentrated. Second, 'high returns to scale and high capital intensity industries are initially more spatially separated than high tech industries, and exhibit a similar pattern to manufacturing as a whole – increasing separation in the 1970s and 1980s followed by increasing clustering in the 1990s.'

Third, between 1970/73 and 1994/97 the 'trend towards dispersion is reflected in 29 out of 36 industries. In contrast, over the same period only 23 out of 36 industries report declining Gini coefficients of concentration.' The spatial separation measure reinforces the findings of a dispersion of EU manufacturing activity. Fourth, in general 'industries with declining Gini coefficients are found to be spatially separating, and vice versa.' This, however, does not hold true for a number of industries that became more concentrated during 1970/73 and 1994/97. These industries are: Textiles, Wearing Apparel, Rubber Products, Motor Vehicles, and Motor Cycles & Bicycles. The authors' note that these industries also became more spatially separated suggesting 'increased concentration in a smaller number of countries at the same time as they see a break-up of trans-national clusters in central Europe.'

Midelfart *et.al.*, (2000), conclude that up to the late 1980s, industries became more dispersed. This trend seems to have reversed itself after EU 1992. 'The aggregate picture masks substantial changes in the location of individual industries. Dividing industries into groups according to their concentration, we see that of those industries that were initially concentrated, a group – largely consisting of high returns to scale industries – have remained concentrated; others, including some relatively high tech, high skill, fast growing industries, have become more dispersed. Of those industries that were initially dispersed, the slower growing and less skilled labour intensive ones have become concentrated in low wage and low skill abundant economies.'[35]

Econometric Analysis

Midelfart *et.al.*, (2000),have found, that the pattern of industry location across the different EU countries is determined the by interaction of industry and country characteristics. To explain these patterns the authors specify a regression equation that includes four country and six industry

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[35] *Ibid.*, p. 30

characteristics. The choice of variables is motivated by the fact that they 'are emphasised by theory,' and 'they all have a significant effect at some point in the time period under consideration.'

TABLE 2.1
INTERACTION VARIABLES

	COUNTRY CHARACTERISTIC	INDUSTRY CHARACTERISTIC
$j = 1$	Market Potential	Sales to industry, % of output
$j = 2$	Market Potential	Intermediate goods, % of total costs
$j = 3$	Market Potential	Economies of scale
	Factor Abundance	*Factor Intensity*
$j = 4$	Agricultural production % GDP	Agricultural input, % of total costs
$j = 5$	Secondary and higher education % GDP	Non-manual workers relative to manual
$j = 6$	Researchers and Scientists % labour force	R&D share in value added

Source: Midelfart *et. al.*,(2000), p. 32

The interaction variables are meant by Midelfart *et.al.*, (2000), to capture 'comparative advantage' and 'new economic geography effects.' The choice of interaction variables is motivated as follows. The variable ($j = 1$) captures the backward linkage; ($j = 2$) captures the forward linkage; ($j = 3$) captures the idea that scale intensive industries locate in 'relatively central locations.' The structure of employment is captured in the variables $j = 3, 4, 5$. The variable ($j = 4$) is an exogenous measure of agricultural abundance; the variables ($j = 5$) captures the skilled labour intensity of the sector; and ($j = 6$) theoretically capture the interaction between an industry's capital endowments and a country's capital intensity.

The model's specified and estimated forms are given as follows:

$$\ln(s_i^k) = \alpha \ln(pop_i) + \beta \ln(man_i) + \sum_j \beta[j](y[j]_i - \gamma[j])(z[j]^k - \kappa[j]) \qquad (2.20)$$

'where s_i^k is the share of industry k in country i; pop_i is the share of EU population living in country i; man_i is the share of total EU manufacturing located in country i; $y[j]_i$ is the level of the jth country characteristic in country i; $z[j]^k$ is the industry k value of the industry characteristic paired with country characteristic j. Finally, α, β, $\beta[j]$, $\gamma[j]$, $\kappa[j]$, are coefficients.' The estimated model is the expanded equation:

$$\ln(s_i^k) = c + \alpha \ln(pop_i) + \beta \ln(man_i) + \sum_j \beta[j]y[j]_i z[j]^k - \beta[j]\gamma[j]z[j]^k - \beta[j]\kappa[j]y[j]_i \qquad (2.21)$$

where, c is a constant term; α ln (pop_i) and β ln (man_i) capture the country size effect; the terms in the summation – $\kappa[j]$, $\gamma[j]$ and $\beta[j]$ – capture the interaction effects between industry and country characteristics.

Results

Midelfart *et.al.*, (2000), found the estimated coefficients on the two country size variables to be significant and show the correct positive sign[36]. The country and industry characteristics show negative coefficient values, as was expected. The authors focussed on the results of the $\beta[j]$ coefficients, 'which measure the effects of the interactions and capture the sensitivity of location patterns to the various country and industry characteristics.' They report the following main conclusions.

First, backward linkages ($j = 1$) are becoming more important over time as a determinant of location. 'Industries that sell a high share of output to industry, are, other things equal, increasingly likely to locate in countries with high market potential.'

Second, forward linkages ($j = 2$) are becoming more important. 'Industries which are heavily dependent on intermediate goods are coming to locate in central regions with good access to intermediate suppliers.'

Third, the coefficient on the interaction variable market potential and economies of scale ($j = 3$), is declining. 'Theory predicts that the forces pulling increasing returns to scale industries into central locations are strongest at the 'intermediate' levels of transport costs.' The declining value of this coefficient over time suggests that trade barriers 'have fallen below intermediate values.' This result suggests that 'high increasing returns industries became better able to serve markets from less central locations.'

Fourth, the interaction variable agricultural production as a share of agricultural costs, ($j = 4$), shows very low significance values over time and becomes significant at the 10% level in 1997. This suggests the growing attainment of comparative advantage in agricultural production.

Fifth, the highly significant value of the coefficient on the interaction variable, education level of the population / non-manual workers relative to manual workers, ($j = 5$), suggests the 'importance of a skilled labour force in attracting skilled labour intensive industries.'

Sixth, the strong interaction between researchers in the labour force and R&D intensity, indicates 'the increasing importance of the supply of researchers in determining the location of high technology industries.'

2.2.10 Conclusion Empirical Literature Review

The empirical literature has focussed on changes in industry concentration in the EU, OECD, and Japan as a consequence of the reduction of barriers to trade and transportation costs. Industry concentration measures, such as, the 'location Gini' (Krugman, 1991a; Brülhart and Torstensson, 1996; Midelfart *et. al.*, 2000) have successfully identified the geographical location of industry. The relative and absolute concentration measures (Amiti, 1997; Haaland *et. al.*, 1999; Forslid *et al.*, 1999) were found to

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[36] The coefficients on ln (*man*) were found to be close to unity.

distinguish between traditional comparative advantage location, and location reflecting the new trade theory of economies of scale. Concentration measures were developed to examine industry concentration as function of industry characteristics to explain the types of industries and geographic destination of their relocation as trade barriers are reduced.

The empirical results suggest that industries with high demand elasticities, the need for large potential markets, low unexploited levels of economies of scale, the need for input-output structures, (forward and backward linkages), skilled labour inputs, and high transport intensities locate in or very close to the core countries (Midelfart *et. al.*, 2000). Industries with low demand elasticities, a high level of unexploited economies of scale, a medium to low need for input-output structures, a proportionally lower skilled to unskilled labour requirement, and low transport intensities tend to move out of core countries and service the larger markets from a mores distant location.

The empirical results provide evidence for the role of the home market (Haaland *et. al.*, 1999; Forslid *et. al.*, 1999; Midelfart, *et al.*, 2000) and identify industry types that locate in core countries and produce for domestic and foreign consumption (Davis and Weinstein, 1998). Strong economic geography effects were found in large Japanese prefectures where low transport costs and perfect labour mobility reinforced agglomeration forces (Davis and Weinstein, 1999). In the EU countries, the lowering of barriers to trade resulted in the industry structures becoming more diverse and specialised due predominantly to countries moving in and out of industries, and less to initial high industry shares (Midelfart *et. al.*, 2000). Finally, European manufacturing industry experienced increased dispersion in the 1980's due to increased manufacturing share in Southern Europe.

Although the empirical research of Midelfart *et.al.*(2002) into the economic geography effects of trade liberalisation has traversed the realm of simulations (Forslid *et.al.*, 1999) in determining the future EU geographic locations of manufacturing activity, there remains a gap in the empirical research that needs to be addressed.

The empirical research has focused on the development of concentration measures to identify industries types with characteristics that are central market oriented based on resource endowment and/or economic geography needs (Haaland *et.al.*,1999; Forslid *et.al.*, 1999; Midelfart *et.al.*, 2000). These studies conclude that changes in the index of industry structures between countries and changes in industry concentration ratios reflect the workings of agglomeration and dispersion forces inherent in the theory of the core periphery model of the new economic geography trade theory. In all cases, the analysis was conducted at the country level. Core countries are identified as central countries with large domestic expenditure levels.

The gap in the empirical literature is the absence of research examining the effects of agglomeration and dispersion forces at the national micro-regional levels. The empirical research at the country level has concentrated on national aggregate information to study the convergence or divergence of industry structures and industry concentration. These methods measure the movement of firms, industries, and manufacturing labour at the national level. However, these variables tell only half the story of the effects of trade liberalisation. The omission in the research is an examination of trade liberalisation effects on changes in manufacturing wages between countries, changes in the costs of production in industries, and changes in capital investments to create economies of scale in production.

To close this gap in the empirical literature, this study develops a national regional model that measures and captures the full effects of agglomeration and dispersion forces at the local regional level where production activity is located. To accomplish this, the core periphery model is modified to a three - region model that can be extended to a multi-region model. Within the framework of this model, the theoretical agglomeration and dispersion forces, that drive the core periphery model, can be analysed at the national regional level. The foundations for this three-region model are laid in the following chapter.

The total size of the labour force in both regions is $A + L = TL$. In terms of shares $A + L = 1$, making the agricultural labour supply equal to $A = 1 - L$, which is distributed evenly over the two regions so that $A = (1 - u)/2$. Agricultural labour is immobile between regions.

Cost of Production

The agricultural industry is one of perfect competition. It produces under conditions of constant returns to scale. Each agricultural worker produces one unit of output and is paid its value marginal product. The model assumes agricultural products are freely traded without transport costs. This makes the price of agricultural products and the wage of agricultural labour the same in both regions, so that $P_A = w_A = 1$ is the numeraire.

The total cost of producing an individual manufactured good i is expressed by the following cost function:

$$L_i = \alpha + \beta q_i \tag{2A.4}$$

where L_i is the quantity of labour employed in the production of good i, the coefficient α represents total fixed cost, β represents a constant marginal cost, and q_i is the quantity of good i produced. Each firm produces one product facing an elasticity of demand equal to σ. Each region has the same technology in manufacturing production. Manufactured goods face the Samuelson 'ice-berg' form of transportation costs. If a product variety is exported from region 1 to region 2, part of each unit melts away during transport with only a fraction $1/\tau$ arriving at its final destination. It is the cost of market access and represents distance. Krugman (1980) notes that the price of a manufactured product is equal to the producer price P_i. Since both regions produce manufactured goods, the price of an exported good includes cost, insurance, and freight (*c.i.f.*) so that consumers in both regions pay $(P_i\tau)$ for imported goods. We assume τ constant for all modes of transport and all varieties of products.

Profit Maximising Behaviour by Firms

A firm's profit π in region 1 is defined as total revenue $p_1.\ q_1$ minus total costs L_1. The profit-maximising equation for a representative firm in region 1 and region 2 is given as:

$$\pi_1 = (p_1 q_1) - (\alpha + \beta q_1) w_1$$
$$\pi_2 = (p_2 q_2) - (\alpha + \beta q_2) w_2$$

A firm will set its market price with a mark-up over marginal cost or its wage rate. The price set by the firm that consumers face in regions 1 and region 2 is given as:

$$p_1 = \frac{(\sigma)}{(\sigma - 1)} \beta w_1 \qquad (2A.5)$$

$$p_2 = \frac{(\sigma)}{(\sigma - 1)} \beta w_2$$

where, respectively, βw_i is marginal cost, and $\sigma / (\sigma - 1)$ is the monopoly mark-up. These two equations are used to compare the relative prices and wages in the two regions. The relative ratios are given by

$$\frac{p_1}{p_2} = \frac{w_1}{w_2} \qquad (2A.6)$$

Optimum Levels of Firm Output

In the long run, with free entry and exit of firms, profits of a representative firm in region 1 are driven to zero so that $d\pi_I = 0$. The profit maximising equation for a representative firm maximising output subject to a cost constraint is given by:

$$\pi_1 = (p_1 q_1) - (\alpha + \beta q_1) w_1 = 0$$

Setting revenues equal to costs gives:

$$p_1 q_1 = \alpha w + \beta w_1 q_1$$

which upon rearranging becomes:

$$q_1 (p_1 - \beta w_1) = \alpha w_1 \qquad (2A.7)$$

Rearranging equation (2A.7) for q_1 and substituting the results of equation (2A.5) gives the following equation for the optimum level of output of an individual firm in region 1:

$$q_1 = \frac{\alpha}{\left(\frac{p_1}{w_1} - \beta \right)} = \frac{\alpha(\sigma - 1)}{\beta} \qquad (2A.8)$$

A similar equation is developed for region 2:

$$q_2 = \frac{\alpha(\sigma - 1)}{\beta}$$

Equation (2A.8) indicates that the optimum level of output per firm in each region is identical.

Number of Goods Produced

To determine the number of goods produced n_i we make use of the full employment level of output, which for region 1 is defined as:

$$L_1 = \sum_{i=1}^{n} (\alpha + \beta q_1) = n_1(\alpha + \beta q_1)$$

The maximum number of manufactured product varieties in region 1 is obtained by rearranging the equation, substituting for βq_1 from equation (2A.8), and solving for n_1. A similar procedure is used to calculate the maximum number of product varieties n_2 for region 2.

$$n_1 = \frac{L_1}{\alpha + \beta q_1} = \frac{L_1}{\alpha\sigma}$$

$$n_2 = \frac{L_2}{\alpha + \beta q_2} = \frac{L_2}{\alpha\sigma}$$

or for the entire country:

$$n_i = \frac{L}{\alpha\sigma}$$

To show that the number of goods produced in each region is proportional to the number of workers we obtain the ratio:

$$\frac{n_1}{n_2} = \frac{L_1}{L_2} \qquad (2A.9)$$

This equation shows that, in equilibrium, the number of firms is proportional to the full-employment number of workers in each region. Since each firm produces a single product variety, the variety of products supplied is proportional to the number of manufacturing workers. A proportional increase in manufacturing workers will therefore increase the variety of goods available to the consumer in equal proportion. The increased supply of product variety and firms, in either region, occurs without an increase in the scale of production, and without a change in the price mark-up over marginal cost.

Short-Run and Long-Run Equilibrium

In the short-run, the distribution of agricultural and manufacturing labour is given. The model has assumed that manufacturing labour is mobile between the regions, and that manufacturing labour will move to the region with the higher real wage. Labour migration can have two effects; first, if labour migration leads to a similar supply of agricultural and manufacturing labour in both regions, real wages will converge. Second, if labour migration results in a concentration of the manufacturing labour force in one region, the real wages will diverge between regions.

Demand

The manufacturing composite index indicates that consumers have a preference for 'love of variety'. Demand for an individual product by a consumer in region 1 for a product from region 1 is given by

$$c_{11} = p_1^{-\sigma} = w_1^{-\sigma}$$

Similarly, demand for a product from region 2 in region 1 is given by:

$$c_{12} = \left(\frac{p_2}{\tau}\right)^{-\sigma} = \left(\frac{w_2}{\tau}\right)^{-\sigma}$$

where $\tau < 1$ and represents the cost of transport to region 1. With positive transport costs, the price of an imported good will always exceed its domestic substitute. The relative demand in both regions for a domestic and imported product is expressed by the ratios:

$$\frac{c_{11}}{c_{12}} = \left(\frac{p_1\tau}{p_2}\right)^{-\sigma} = \left(\frac{w_1\tau}{w_2}\right)^{-\sigma} \qquad (2A.10)$$

$$\frac{c_{22}}{c_{21}} = \left(\frac{p_2\tau}{p_1}\right)^{-\sigma} = \left(\frac{w_2\tau}{w_1}\right)^{-\sigma}$$

Equilibrium Income and Expenditures

Total manufacturing labour income in either region is the product of total wages paid to manufacturing labour times the full employment number of labourers. There are no savings and no taxes so that total manufacturing income is spent on the consumption of manufacturers. This relationship is expressed in the following equation:

$$L = u$$

$$wL = \sum_{i=1}^{n} c_i = n_i p_i c_i$$

where wL is the value of total labour income in the two regions and the term $n_i p_i c_i$ is the value of consumption expenditures on all varieties of manufactured products. Each region has its own expenditure function. Assuming no exchange of goods between the regions their respective expenditure functions will be:

$$w_1 L_1 = n_1 p_1 c_1$$

$$w_2 L_2 = n_2 p_2 c_2$$

With the exchange of goods between regions, the expenditure function of both regions will include imported goods. Let z_{11} represent relative expenditure in region 1 on home products to that of foreign products and z_{12} the relative expenditure of region 2 on its domestic and foreign products. Then,

$$z_{11} = \left(\frac{n_1}{n_2}\right)\left(\frac{p_1 \tau}{p_2}\right)\left(\frac{c_{11}}{c_{12}}\right) = \left(\frac{L_1}{L_2}\right)\left(\frac{w_1 \tau}{w_2}\right)^{-(\sigma-1)} \tag{2A.11}$$

$$z_{12} = \left(\frac{L_1}{L_2}\right)\left(\frac{w_1}{w_2 \tau}\right)^{-(\sigma-1)} \tag{2.12}$$

The equation shows that relative expenditure by either regions will be determined, *ceteris paribus*, by the relative size of the number of varieties produced, and hence the relative number of firms.

Total income in region 1 is determined by total spending of its manufacturing labour on region 1 products plus the spending by manufacturing labour in region 2 on region 1 products. Total income in region 2 is determined in a similar manner. These relationships are expressed as follows:

$$w_1 L_1 = u\left[\left(\frac{z_{11}}{1+z_{11}}\right)Y_1 + \left(\frac{z_{12}}{1+z_{12}}\right)Y_2\right] \tag{2A.13}$$

$$w_2 L_2 = u\left[\left(\frac{1}{1+z_{11}}\right)Y_1 + \left(\frac{1}{1+z_{12}}\right)Y_2\right] \tag{2A.14}$$

Total income in each region depends on the distribution of manufacturing labour and their respective wages. Given that the wage rate of agricultural labour is the numeraire, the total income equation for region 1 and region 2 becomes:

$$Y_1 = \frac{1-\mu}{2} + w_1 L_1 \qquad (2A.15)$$

$$Y_2 = \frac{1-\mu}{2} + w_2 L_2 \qquad (2A.16)$$

Krugman (1991b) points out that the set of equations (2A.11) – (2A.16) is a system that determines nominal wages w_1 and w_2 in both regions.

The respective price index of manufacturers for consumers in region 1 and region 2 is given by the price index equations:

$$P_1 = \left[f w_1^{-(\sigma-1)} + (1-f)\left(\frac{w_2}{\tau}\right)^{-(\sigma-1)} \right]^{-1/(\sigma-1)} \qquad (2A.17)$$

$$P_2 = \left[f\left(\frac{w_1}{\tau}\right)^{-(\sigma-1)} + (1-f) w_2^{-(\sigma-1)} \right]^{-1/(\sigma-1)} \qquad (2A.18)$$

where $f = L_1 / \mu$ is the share of the manufacturing labour force in region 1. The price index equation can be reformulated given that $L_1 + L_2 = 1$ so that $L_1 = 1 - L_2$, and both L_1 and $L_2 < 1$.

$$P_1 = \frac{1}{\left[L_1 (w_1)^{-(\sigma-1)} + L_2\left(\frac{w_2}{\tau}\right)^{-(\sigma-1)} \right]^{1/(\sigma-1)}} \qquad (2A.17a)$$

$$P_2 = \frac{1}{\left[L_1\left(\frac{w_1}{\tau}\right)^{-(\sigma-1)} + L_2 (w_2)^{-(\sigma-1)} \right]^{1/(\sigma-1)}} \qquad (2A.18a)$$

The price index equations nicely reveal the regional price effects of an increase in a region's share of the manufacturing labour force. In equilibrium, relative wages are the same in both regions. Transport costs are positive but constant. A migration of manufacturing labour from region 2 to region 1 results in a decline of the P_1, while P_2 increases.

Real wages ω_i in either region are defined by the following two equations:

$$\omega_1 = w_1 P_1^{-u} \tag{2A.19}$$

$$\omega_2 = w_2 P_2^{-u} \tag{2A.20}$$

so that a decline in the price index in region 1 causes real wages to rise in region 1. A price increase in region 2, due to the aforementioned labour migration from to region 1, will result in a rise in the price index P_2, and thus a decline in real wages in that region.

FUJITA, KRUGMAN, AND VENABLES' (1999) NORMALISED CORE PERIPHERY MODEL

Consumer Behaviour

Consumers maximise their tastes via a Cobb-Douglas utility function for both manufacturing, and agricultural products. This utility function is given by:

$$U = M^{\mu} A^{1-\mu} \tag{2B.1}$$

where M is a composite index of manufacturing products, and A represents consumer expenditure on agricultural products. The share of consumer expenditure on manufacturing products is given by u, and the share of consumer expenditure on agricultural products is give by $(1 - \mu)$.

The manufacturing aggregate contains a large variety of products m_i, and is defined by constant-elasticity-of-substitution functions CES. The manufacturing aggregate is defined as:

$$M = \left[\sum_{i=1}^{n} m_i^{\rho} \right]^{\frac{1}{\rho}} \tag{2B.2}$$

where n represents the total number of varieties produced, and m_i the consumption of product i from the total variety of products available to the consumer from the manufacturing aggregate M.

The parameter ρ is an elasticity measure that represents the consumer's preference for a particular product variety in the basket of manufacturing products. This parameter takes on a value such that $0 < \rho < 1$. A parameter value of $\rho \approx 1$, means that the consumer perceives the attributes of one particular product as a near perfect substitute for a competitive product. It implies little or no perceived product differentiation. A parameter value of $\rho \approx 0$, on the other hand, means that the consumer perceives the attributes of the product as being highly differentiated from a competitive product.

The elasticity of substitution between any two varieties of manufactured products is given by σ, where $\sigma \equiv 1/(1 - \rho)$, and the value of $\sigma > 1$. This implies that $\rho \equiv (\sigma - 1)/\sigma$. A high elasticity of substitution between products reflects a high elasticity of demand, while a low elasticity of substitution implies a low elasticity of demand, and a highly differentiated product.

Given consumer income Y and the prices of agricultural products p_i^A, and manufacturing products p_i^M, the consumer has to maximise utility in equation (2B.1) subject to budget constraint given by:

$$p_i^A A + \sum_{i=1}^{n} p_i^M m_i = Y$$

There are two steps in the budgeting procedure. The first step is to choose each manufacturing product m_i from the continuum of products in the manufacturing aggregate so that the consumer minimises the cost of attaining M. The consumer minimisation problem for manufacturing is formulated as follows:

$$\min \sum_{i=1}^{n} p_i^M m_i \text{ subject to } \left[\sum_{i=1}^{n} m_i^{\rho}\right]^{1/\rho} = M \tag{2B.3}$$

This consumer minimisation problem results in a first-order condition expressed by the ratio:

$$\frac{m_i^{\rho-1}}{m_j^{\rho-1}} = \frac{p_i^M}{p_j^M} \tag{2B.4}$$

which is the marginal rate of substitution to price ratios for a given pair of products i, j. This results in the expression:

$$m_i = m_j \left(\frac{p_j^M}{p_i^M}\right)^{1/(1-\rho)}$$

Substituting this result into the original budget constraint from (2B.2)

$$M = \left[\sum_{i=1}^{n} m_i^{\rho}\right]^{\frac{1}{\rho}}$$

provides,

$$m_j = \frac{(p_j^M)^{1/(\rho-1)}}{\left[\sum_{i=1}^{n} (p_i^M)^{\rho/(\rho-1)}\right]^{1/\rho}} M \tag{2B.5}$$

This equation (2B.5) is the compensated demand function for the j^{th} manufactured product variety.

The expression for minimising the cost of attaining M can now be found. We know that expenditure on the j^{th} variety is $p_j^M m_j$. Substituting this expression in equation (2B.5) we obtain,

$$\sum_{j=i}^{n} p_j^M m_j = \left[\sum_{1=i}^{n} (p_i^M)^{\rho/(\rho-1)}\right]^{(\rho-1)/\rho} M \tag{2B.6}$$

where the term on the right hand side of the equation represents the product of the composite manufacturing aggregate M, and the manufacturing price index. The product of these two variables equals the expenditure on manufacturing. Now, substituting $\rho \equiv (\sigma - 1)/\sigma$ with $\sigma \equiv 1/(1-\rho)$, where σ is the elasticity of substitution for manufacturing, and letting G denote the symbol for the manufacturing price index, we obtain the following expression for the manufacturing price index:

$$G \equiv \left[\sum_{1=i}^{n} (p_i^M)^{1-\sigma} \right]^{1/(1-\sigma)} \qquad (2B.7)$$

This identity shows that the minimum cost of any product in the manufacturing goods composite index, M, is given by the price index G. A price index represents an expenditure function. By using the expression for the manufacturing price index in equation (2B.7) and substituting into (2B.5) after the necessary exponential substitutions, gives a demand expression for the m_ith manufacturing variety:

$$m_i = \left(\frac{p_j^M}{G} \right)^{1/(\sigma-1)} M = \left(\frac{p_j^M}{G} \right)^{-\sigma} M \qquad (2B.8)$$

The second step in the consumer choice problem is to maximise utility by optimally allocating income between agriculture and manufacturing products. The consumer must maximise

$$U = M^{\mu} A^{1-\mu} \text{ subject to the constraint } GM + p^A A = Y \qquad (2B.9)$$

The first-order maximisation result provides the uncompensated demand functions for agriculture

$$A = \frac{(1-\mu)Y}{p^A} \qquad (2B.10)$$

and for each variety of manufacturing m_i the demand expression becomes,

$$m_j = \mu Y \frac{(p_j)^{-\sigma}}{G^{-(\sigma-1)}} \qquad \text{for } j \in [0, n] \qquad (2B.11)$$

An indirect utility function can now be obtained from the consumer's maximisation problem. Substituting equations (2B.10) and (2B.11) into equation (2B.1) we obtain,

$$U = \frac{\mu^{\mu}(1-\mu)Y^{1-\mu}}{G^{\mu}(p^{A})^{(1-\mu)}} \tag{2B.12}$$

where the term in the denominator $G^{\mu}(p^{A})^{(1-\mu)}$ is the cost of living index. A decline of either agricultural or manufacturing prices will increase consumer utility maximisation.

The indirect utility function (2B.12) can also be used to show the effect on consumer welfare as a consequence of an increase in the availability of more manufactured product varieties. Assuming that all manufacturers are supplied at the same price so that $p_i^M = p_j^M$ the price index in equation (2B.7) becomes,

$$G = \left[\sum_{1=i}^{n}(p_i^M)^{1-\sigma}\right]^{1/(1-\sigma)} = p_i^M n_i^{1/(1-\sigma)} \tag{2B.13}$$

$$G^{1-\sigma} = \frac{G}{G^{\sigma}} = p_i^M n_i$$

This result is important for a number of reasons. First, it shows that an increase in the number of varieties available reduces the manufacturing price index, thereby increasing welfare. Second, the responsiveness of product price depends on the elasticity of substitution between product varieties σ. The more differentiated product varieties are, the lower will be the value of σ, and the larger the reduction in the price index as a result of more product varieties being supplied. Third, an increase in substitute products – varieties – will cause the demand curves for existing varieties to shift downward. This can be seen in equation (2B.11). An increase in the number of varieties, *n*, reduces the price index $G^{-(1-\sigma)}$, and increases m_i. The increased product market competition through the availability of more varieties, causes a downward shift of the demand curves for existing products, and reduces the sales of these products. Fourth, this price effect is set in motion by agglomeration forces through the clustering of industries.

The income equations of the two regions are defined by the following two equations:

$$Y_1 = \mu\lambda w_1 + \frac{1-\mu}{2} \tag{2B.14}$$

$$Y_2 = \mu(1-\lambda)w_2 + \frac{1-\mu}{2} \tag{2B.15}$$

The price index equations are derived from equations (2B.14) and (2B.15), after substitutions of equations (2A.6) and (2A.9), and the condition that $L_s^M = \mu\lambda_{sr}$, lead to the price index equations for region 1 and region 2, which become;

$$G_1 = [\lambda w_1^{1-\sigma} + (1-\lambda)(w_2 T)^{1-\sigma}]^{1/(1-\sigma)} \tag{2B.16}$$

$$G_2 = [\lambda (w_1 T)^{1-\sigma} + (1-\lambda) w_2^{1-\sigma}]^{1/(1-\sigma)} \tag{2B.17}$$

The wage equation for region 1 and region 2 are developed from equations (2B.16) and (2B.17). Each equation is expanded to incorporate the other region's price index and the cost of transportation. The resulting wage equations are as follows;

$$w_1 = [Y_1 G_1^{\sigma-1} + Y_2 G_2^{\sigma-1} T^{1-\sigma}]^{1/\sigma} \tag{2B.18}$$

$$w_2 = [Y_1 G_1^{\sigma-1} T^{1-\sigma} + Y_2 G_2^{\sigma-1}]^{1/\sigma} \tag{2B.19}$$

The real wage equations are derived from equations (2B.18) and (2B.19). Since the price of agricultural products is assumed to be the numeraire in this normalized model, such that $p^A = 1$, the agricultural price variable is eliminated from the real wage equations. The real wage equations are then defined as;

$$\omega_1 = w_1 G_1^{-\mu} \tag{2B.20}$$

$$\omega_2 = w_2 G_2^{-\mu} \tag{2B.21}$$

The normalised core periphery model is defined by equations (2B.14) to (2B.21), and consists of eight equations and eight endogenous variables.

Krugman's Locational Gini Coefficient

The 'locational Gini coefficient' is a statistical measurement used to construct a Lorenz curve. A Lorenz curve correlates the cumulative percentage value of any two variables. Krugman (1991a) describes how a locational Gini coefficient is calculated. To measure the concentration of production activity in a region, Krugman measures the relationship between the cumulative percentage value of a region's share of manufacturing employment, and the cumulative percentage value of a region's share of employment in a given industry *i*. The measurement procedures to reproduce the calculations in Table 2C.1 consist of six steps.

TABLE 2C.1
LOCATIONAL GINI COEFFICIENT: RANKING IN *ASCENDING* ORDER

Region	$RS_j^{(me)}$	$RS_i^{(ei)}$	LC_i	$C(RS_j^{(me)})$	$C(RS_i^{(ei)})$	$C(LG_{i,j})$	$LG_{i,j}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R_1	0.2	0.5	$LC_1 = RS_1^{(me)} / RS_1^{(ei)} = 0.2/0.5 = 0.4$	0.2	0.5	0.714	0.714
R_2	0.4	0.4	$LC_2 = RS_2^{(me)} / RS_2^{(ei)} = 0.4/0.4 = 1.0$	0.6	0.9	0.600	0.500
R_3	0.4	0.1	$LC_3 = RS_3^{(me)} / RS_3^{(ei)} = 0.4/0.1 = 4.0$	1.0	1.0	0.500	0.200
	Step 1		Step 2	Step 3		Step 4	

The three regions R_i for (i = 1,2, and 3) are listed in column (1). A region's share of manufacturing employment symbolised by $RS_j^{(me)}$ is found in column (2). In column (3) we find a regions share of employment in industry *i*, symbolised by $RS_i^{(ei)}$. Column (4) is the calculated location coefficient used to rank the regions in either *ascending* or *descending* order. In columns (5) and (6) we find the cumulated values of the respected shares in *ascending* order. In columns (7) we find the cumulated 'location Gini' coefficient calculated according to equation (2C.2). Finally, column (8) shows the calculated values of the location Gini based on the values in columns (2) and (3). The steps in the calculation of the above values are given below.

STEP 1

The first step consists of two parts; a) to calculate region *j*'s share of total manufacturing employment as a percent of total national manufacturing employment, $RS_j^{(me)}$; and, b) to calculate region *j*'s share of employment in industry *i* as a percent of total employment in industry *i*, $RS_{i,j}^{(ei)}$. The respective values of these two variables that Krugman uses in his example are listed in columns (2) and (3) of Table 2C.1.

STEP 2

The second step requires the calculation of the location coefficient. The location coefficient is measured with the ratio:

$$LC_{i,j} = \frac{RS_j^{(me)}}{RS_{i,j}^{(ei)}} \qquad (2C.1)$$

The numerical value of this ratio is then used by Krugman to rank the regions. The values of the location coefficients are found in column (4) of Table 2C.1.

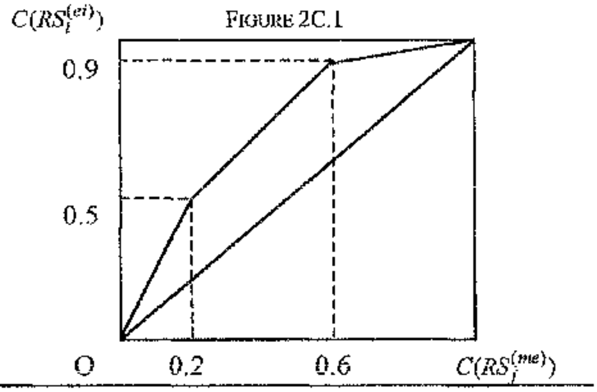
STEP 3

Step three in Krugman's example, ranks the regions in *ascending* order, and adds the percentage values of the respective variables. The cumulative values of the two variables are listed in columns (5) and (6), and respectively sum to unity. This calculation makes use of the data in columns (2) and (3) of Table 2C.1.

STEP 4

Krugman's (1991a, p.56) fourth step plots the cumulated values from columns (5) and (6) on the vertical and horizontal axis of Figure 2C.1, which is reproduced below.

FIGURE 2C.1



Source: Krugman (1990), *Geography and Trade*, p.56

The cumulative percentage value of a region's share of manufacturing employment, $C(RS_j^{(me)})$, is measured on the horizontal axis, while the cumulative percentage value of a region's share of employment in the widget industry, $C(RS_i^{(ei)})$, is measured on the vertical axis.

The figure tells us that 20% of the country's manufacturing employment found in region 1, represents 50% of employment in the widget industry. The next 40% of manufacturing employment, found in region 2, represent the next 40% of employment in the widget industry. The final 40% of manufacturing employment is located in region 3, and is only 10% of total employment in the widget industry. The curved line OP represents the relationship between the cumulative percentage values of these two variables. These calculations indicate that employment in the widget industry is largest in region 1, and that region 1 has a concentration of widget industry production activity.

STEP 5

To calculate the locational Gini coefficients, we use the ratio presented by Jacobson and Andréosso-O'Callaghan (1996). The ratio [using our symbolism] is defined as follows:

$$C(LG_{i,j}) = \frac{C(RS_{i,j}^{(ei)})}{[C(RS_{i,j}^{(ei)}) + C(RS_{j}^{(em)})]} \qquad (2C.2)$$

The calculation of the locational Gini coefficient makes use of the cumulative percentage values of the variables listed in columns (5) and (6) of Table 2C.1. The estimates of this ratio are listed in column (7) of Table 2C.1. The region with the highest percentage of regional employment in the widget industry relative to the region's percentage share of total manufacturing employment will have, by definition (Krugman, 1991a), the highest locational Gini coefficient value, and thus the highest concentration of that industry.

STEP 6

Our estimates show that region 1 has the highest concentration with a $C(LG_{i,j}) = 0.714$, and region 3 the lowest $C(LG_{i,j}) = 0.500$. This outcome is contrary to Krugman's (1991a, p.56) intended illustration. 'An industry that was not localised at all, but simply spread out in proportion to overall employment, would have an index of 0; one that is concentrated almost entirely in a region with small overall employment would have an index close to 0.5'.

However, if we use the non-cumulated value of equation (2C.2), and use the data in columns (2) and (3), we obtain the same region rankings as if we used the cumulated values. Figure 2C.1 is a mirror image of the Lorenz curve when regions are ranked in descending order. This is illustrated in the following Table 2C.2.

In the following example, the six steps performed in calculating the values in Table 2C.2 are the same as before. The values of the locational Gini coefficients that form the Lorenz curve are obtained by ranking the values of the location coefficient LC_i in *descending* order as is illustrated in column (4) of Table 2C.2. A high location coefficient means a relatively low share of regional employment in a given industry, while a low value of the location coefficient means a relatively large share of regional employment in an industry.

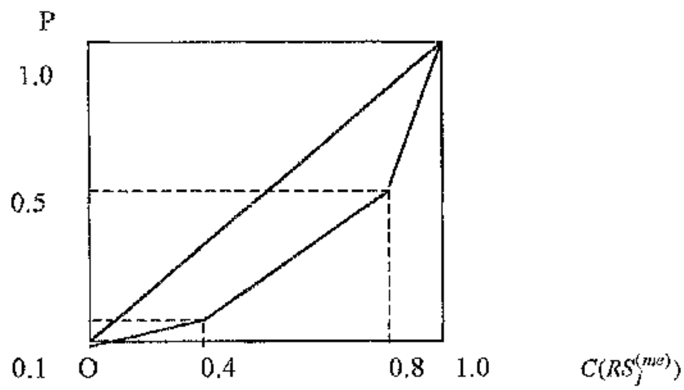
In Krugman's example, region 3 has a low share of regional employment in the widget industry, but a relatively higher share of regional manufacturing employment, resulting in a high value of the location coefficient. region 1, on the other hand, has a high share of regional employment in the widget industry, and a relatively lower share of regional manufacturing employment, resulting in a low value of the location coefficient. The location coefficient relates regional industry employment to the size of overall regional employment.

TABLE 2C.2
LOCATIONAL GINI COEFFICIENT: RANKING IN *DESCENDING* ORDER

Region	$RS_j^{(me)}$	$RS_i^{(ei)}$	LC_i	$C(RS_j^{(me)})$	$C(RS_i^{(ei)})$	$C(LG_{i,j})$	$LG_{i,j}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R_3	0.4	0.1	$LC_3 = RS_3^{(me)} / RS_3^{(ei)} = 0.4/0.1 = 4.0$	0.4	0.1	0.200	0.200
R_2	0.4	0.4	$LC_2 = RS_2^{(me)} / RS_2^{(ei)} = 0.4/0.4 = 1.0$	0.8	0.5	0.385	0.500
R_1	0.2	0.5	$LC_1 = RS_1^{(me)} / RS_1^{(ei)} = 0.2/0.5 = 0.4$	1.0	1.0	0.500	0.714

Ranking the regions in *descending* order by locational coefficient results in a set of different percentage cumulative values of the variables than if the regions were ranked in ascending order. A plot of these values, as demonstrated in Figure 2C.2, results in a Lorenz curve and the respective values of the cumulative locational Gini coefficients $C(LG_{i,j})$ with a possible minimum value of 0, and a maximum value of 0.5. These values can only be obtained when the locational Gini coefficient is calculated using the percentage cumulative values of the two variables, based on *descending* ranking order of the location coefficient.

$C(RS_i^{(ei)})$ FIGURE2C.2



Source: Author's own construction using Krugman data

The Lorenz curve of Figure 2C.2, illustrates that the first 40% of manufacturing employment, located in region 3, represents 10% of total employment in the widget industry. The next 40% of manufacturing employment is located in region 2, and represents 40% of total employment in the widget industry. The final 20% of total national manufacturing employment found in region 3, and represents 50% of employment in the widget industry in a given country. This region has the lowest location coefficient and the highest concentration of the widget industry in the country.

The value of the cumulative locational Gini coefficient is calculated to be:

$$C(LG_{i,j}) = \frac{C(RS_{i,j}^{(ei)})}{[C(RS_{i,j}^{(ei)}) + C(RS_{j}^{(em)})]} = \frac{1}{1+1} = \frac{1}{2} = 0.5 \quad (2C.3)$$

This indicates that the highest concentration of widget production is found in the region with a location Gini value equal to 0.500.

The locational Gini coefficient can also be calculated using original data in columns (2) and (3). The results are illustrated in column (8) of Table 2C.2. As in Table 2C.1, this method avoids the three steps of calculating the value of the location coefficient, ranking the data in descending order, and calculating the percentage cumulative values of the two variables. The procedure used in column (8), calculates location Gini-values that allow for the 'post facto' ranking of the regions in descending order based on the estimated regional Gini-concentration values. The range of the locational Gini coefficients measured in this way is such that $0 < LG_{i,j} < 1$.

APPENDIX 2D

TABLE 2D.1
TRADE DISTORTIONS, ECONOMIES OF SCALE, VALUE ADDED SHARES, AND FACTOR INTENSITIES

	Trade Distortions				Use of Intermediates[2]				Value Added Shares and Factor Intensity Ratios[3]				
	Low	Unweighted Mean	High	Returns to Scale[1]	Own Input Share	Interm. Share	Own Share of Interm.	Service Input Share	Unskilled Labour	Skilled Labour	Capital	Unskilled / Skilled Ratio	Labour / Capital Ratio
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*
Chemicals	4.7	8.7	16.0	0.24	0.297	0.603	0.493	0.163	0.438	0.278	0.285	1.58	2.51
Machinery	2.6	3.5	3.9	0.20	0.169	0.489	0.346	0.145	0.478	0.313	0.210	1.53	3.76
Transport Equipment	2.3	3.1	4.2	0.26	0.145	0.570	0.254	0.138	0.540	0.268	0.198	2.02	4.09
Metals	3.8	6.0	9.0	0.16	0.366	0.634	0.577	0.169	0.565	0.233	0.203	2.43	3.94
Wood Products	3.8	6.2	-11.1	0.12	0.268	0.555	0.483	0.156	0.530	0.245	0.228	2.16	3.41
Food Products	14.4	20.1	31.1	0.08	0.158	0.655	0.241	0.116	0.450	0.185	0.365	2.43	1.74
Textiles	4.3	6.2	8.8	0.06	0.294	0.561	0.524	0.131	0.595	0.175	0.235	3.40	3.28
Leather and Products	3.6	4.6	5.5	0.06	0.187	0.543	0.344	0.117	0.603	0.175	0.225	3.44	3.46
Minerals	2.4	9.3	14.9	0.10	0.130	0.486	0.267	0.205	0.455	0.195	0.353	2.33	1.84
Other Manufacturing	3.0	4.1	4.8	0.08	0.026	0.335	0.078	0.095	0.553	0.240	0.205	2.30	3.87
Mean	4.5	7.2	8.7	0.136	0.204	0.543	0.376	0.143	0.521	0.231	0.251	2.36	3.19

Source: Forslid *et al*., (1999). Table 3; Table 4; and Table 5

Percent reduction in average cost (AC) with a one-percent increase in output.

Averages for the Western European Region.
Own Input Share = input from own sector as a share of output value; *Intermediate Share* = total use of intermediates from all sectors as a share of value of output; *Own Share of Intermediates* = the dependence on own relative to other sectors' inputs (Own Share relative to Intermediates Share. A number higher than 0.5 indicates inputs from own industry are more important than inputs from all other industries together); and, *Service Input Share* = use of private and public services – which by assumption are non-traded goods – as a share of output.

European Averages.

CHAPTER 3
DEFINING AND CLASSIFYING THE REGIONS

3.1 INTRODUCTION

The objective of this chapter is threefold; first, to develop a regional nomenclature as developed by regional economists; second, to define the term 'an agglomerate' as the central place of production concentration; and third, to categorise and classify national regions in each of the EU countries.

3.2 A NOMENCLATURE FOR NATIONAL REGIONS

In past studies by regional economists, countries were divided into national regions (Paelinck and Nijkamp, 1975). In these studies, regions were geographical areas of unequal size whose boundaries are determined either by their geography or by an administrative area. In this dissertation, we will adopt this nomenclature and apply it to the core periphery model.

A region has a vector of measurable and quantifiable characteristics such as natural resource endowments, population demographics, industrial structures, infrastructure, institutions, villages, towns, cities and metropolises. Not all national regions are equally endowed with elements in this vector of characteristics. The disparate attributes of the regions reflect the evolution of economic activity due to geography, location, historical economic development, and entrepreneurial behaviour. National regions may be ranked on the basis of the quantitative values of their variables thereby providing a portrait of the range of economic (manufacturing) activity as it is dispersed (or concentrated) over the national regions.

Regional economists have traditionally distinguished between two classes of regions, *administrative* and *programming* (Paelinck and Nijkamp, 1975). The level of economic activity in an administrative region can cause it to be classified into one of four categories – *polarised, contiguous, periphery,* and *natural.* A programming region is a combination of one or more administrative regions.

3.2.1 Administrative Region

A country is politically defined by its national borders, as are its provinces, regions, and counties. An *administrative region* is an area defined by political and/or administrative boundaries. Political boundaries are national borders, while administrative boundaries are regional borders separating regions within a nation. An administrative region defines an individually circumscribed geographic area with an economic structure. An administrative region's economic structure may not always be confined within its administrative boundaries. Intersectoral linkages may create input-output relationships of an economic structure to extend beyond a single administrative boundary into an adjoining administrative region, thus creating interregional economic linkages.

Administrative regions are significant since they serve as a starting point for government intervention and planning. Economic policy aimed at a specific administrative region may have no effect on that region if the intersectoral and interregional linkages are not clearly identified (Paelinck and

Nijkamp, 1975). In the EU, regional policy measures through the European Reconstruction and Development Fund (ERDF) aim at the administrative region and its counties.

3.2.2 Programming Region

A *programming region* consists of one or more counties within an administrative region, or a combination of adjacent counties in adjoining administrative regions or one or more administrative regions in their totality. A programming region is a clearly defined geographic area that is targeted for a particular regional development programme. Its geographic boundaries are defined such that planning objectives may be efficiently accomplished.

Programming regions are 'target regions' where specific economic policy measures can stimulate economic growth. An optimal policy for a programming region requires a clear identification of both the economic objective to be attained, and the structure of the regional economy as defined by its input-output linkages. Regional input-output structures could differ because of different technological and factor endowments. The economic effects of such stimulation should transmit growth to adjoining counties and regions, and thus affect industries through their interregional and intersectoral linkages (Boudeville, 1963).

3.2.3 Polarised Region

A *polarised region* is a region '... that consists of interdependencies between economic and spatial elements'[37]. The economic environment manifests a high degree of external economies, and intersectoral commodity and factor flows. The spatial element refers to traffic, transportation, and communications. The degree of polarisation depends on the intensity and integration of all economic activity within the region. It can be characterised as being a singular physical area with an interwoven pattern of economic activity between industrial sectors reflecting forward and backward linkages. It is the spatial integration of interdependent heterogeneous production activities, which can create structural (compositional) inter-industry differences between these types of regions, leading to disparities in the levels of regional incomes.

Boudeville (1963)[38] has argued that a polarised region should satisfy the following three criteria of; i), a total population of more than four million people; ii), an integrated industrial complex; and iii), a relatively high volume of exports. Boudeville's population criterion recognises not only the need for a large labour force with purchasing power, but also imposes a boundary on the minimum size of a polarised-region.

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[37] (Perroux 1955, Boudeville, 1963) in Paelinck and Nijkamp 1975
[38] In Paelinck and Nijkamp, (1975)

3.2.4 Contiguous Region

A *contiguous region* is defined as a region that is adjacent to, and borders on, a polarised region. It possesses an economic structure that is dependent on that of a polarised region. Furthermore, a contiguous region is an administrative region with intersectoral and interregional input-output linkages to the polarised region. However, the level of economic activity in the contiguous region is weaker than that in the polarised region (Paelinck and Nijkamp, 1975). Consequently, this means, that we cannot assume that regional classification will automatically result in the defining of autonomous core and periphery regions. An economic input-output structure does not necessarily have to be confined to one administrative region, but can extend to an adjoining region.

3.2.5 Periphery Region

Regional economists note that a *periphery region* is an outlying region and, as its name suggests, geographically distanced in space from a polarised region. The spatial geographic location of a periphery region is such that strong intersectoral and interregional economic linkages between it and a polarised region are not strongly developed. Krugman (1980, 1991a, 1991c, 1991d) has described a periphery region as 'a geographic area with a low population density, consisting mainly of farmers, and a small share of manufacturing labour vis-à-vis the polarised region.' However, the European Commission (1994) describes periphery regions as national border and coastal regions with low levels of economic activity. These pre-integrated regions are peripheral because their neighbouring foreign regions have a different social, economic, legal, and political system. These differences restrict trade, and limit the complete development of interregional demand and supply linkages (Krugman and Venables, 1996; Holmes, 1997).

Brülhart and Torstensson (1996) contend that a country's periphery region, such as a coastal region or border region, could also be classified as a polarised region since such regions function as trade routes with the rest of the world. Geographic distance, high transportation costs, and barriers to trade encourage the development of peripheral coastal polarised regions. Similarly, national internal border peripheral regions may become polarised regions due to an abundance of natural endowments, economic historical development, and qualitative and quantitative barriers to trade. In a pre-integration situation, their economic development is contingent upon their industrial structure, and trade with foreign regions. Therefore, it would thus be erroneous to assume *a priori* that all peripheral regions have the characteristics of natural regions.

3.2.6 Natural Region

A *natural region* is typified by geographical and physical characteristics such as climate, soil conditions, land fertility, height above sea level, and geographic location in space. The economic activities associated with natural regions include agriculture, forestry, mining, shipbuilding, and tourism.

A natural region is relevant for determining the optimal spatial dispersion of agricultural production, in order to minimise the transportation costs of agricultural products. Forestry and mining are fixed natural resource endowments, while shipbuilding is located along coastal waterways. A natural region exhibits wide population dispersion with many small urban areas characterised by processing and local manufacturing industry and by low per capita income levels.

3.2.7 A Three-Region Classification for National Administrative Regions

The early trade literature (Krugman, 1980, 1981a) concerned itself with trade between countries, and emphasised trade effects on the 'home market' or the 'larger market'. This line of theoretical analysis of international trade can be equally extended to trade between regions in a large geographic area such as the EU. The theory would then apply to interregional trade with highly populated core regions being the 'home markets'.

In this study the regional nomenclature will be as follows: a polarised region will be called a *core region*; and a contiguous region will be known as an *adjacent region*. The nomenclature for the *periphery region* remains the same, and the term periphery includes the natural regions. This creates a three-region classification of national administrative regions. The advantage of this classification lies in the ease with which it permits the international comparison of the intensity of economic activity between comparable administrative regions.

3.3 AN AGGLOMERATE

An urban agglomerate is defined as a densely populated urban centre with an industrial complex. This definition captures both the regional demand and supply forces, and the pecuniary agglomerate advantage of production concentration. A core region denotes, by definition, an administrative geographic area with a high population density and a high concentration of industrial activity. In this study, *an agglomerate* is defined as a core region with one or more urban agglomerates. The term core region is therefore synonymous with the term agglomerate and Krugman's (1991b) home market concept.

In his analytical framework of industry concentration, Weber (1909) introduced the concept of 'spatial agglomerate economies' as a determining factor in the location decision of a firm. Agglomerate economies arise from the extra reduction in production, transportation, and communication costs, due to the clustering of intermediate and final goods-producing firms in one location. Transportation and communication costs are all costs incurred through firms' interaction with their input and output markets. These costs can be minimised if firms cluster, thereby creating economies of scale. The new trade literature refers to these benefits as 'pecuniary agglomerate advantage'.

Lösch (1954), like Krugman (1978), has argued for the importance of population density in agglomerate formations. He noted that,

> *'Spatial agglomerations such as towns are the results of agglomerative forces in both the production and the consumption sphere. These agglomerative forces may be of a different nature, for instance economies of scale, external economies, and psychological attraction forces. In this way, the general interdependent location problem is closely linked up with the analysis of urban*

Lösch also recognised the relevance of regional non-uniform utility functions. Krugman (1978), on the other hand, assumes a uniform utility function across regions. In describing and discussing Lösch's location theory, Paelinck and Nijkamp (1975) point out that,

> *'The existence of agglomerative forces leads to the concentration of different production units in one spatial point. This concentration of production is controlled by the minimisation of transportation costs within the entire industrial complex. The assumption of agglomeration advantages and of minimisation of integrated transportation costs, ... leads to bundles of industrial centres and cities, in which a maximum number of different individual production units will be located at the same place. In this way, the economic landscape will show areas with a high and a low industrial and urban concentration.'*

Lösch implicitly recognised the importance of backward and forward demand linkages in agglomerate formation. As previously stated, his use of the term 'psychological attraction forces' indicates individual regional locational utility preferences for both management and labour (Ludema and Wooton, 1997). Lösch's most salient contribution is the explicit recognition of the role of large urban centres, which Krugman refers to as the 'home market'. In this study, the home market concept is synonymous with both that of 'an agglomerate' and a core region.

Economic integration can affect the industrial composition of agglomerates and has raised the issue of agglomerate stability. Krugman and Venables (1996) have discussed and recognised the importance of input-output structures for industrial districts. They conclude that a reduction in barriers can result in the relocation of industry. More specifically, they argue that intermediate goods producers will relocate to those agglomerates with the highest concentration of their final goods producers. Similarly, final goods producers may relocate to industrial complexes where similar type firms in the industry are located. This, however, would not necessarily affect the stability of the agglomerate, but instead, through the interregional relocation of intermediate and final goods suppliers, it would transform the composition of the industrial complexes. This would result in a higher concentration of a particular industry in any given regional agglomerate[39], and can result in complete specialization, thereby changing the pattern of inter-agglomerate trade from *intra* to *inter* industry.

The recomposition of industrial structures does not necessarily imply a core periphery outcome. The theoretical literature has proven that industries will not relocate collectively, leaving a region without

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[39] The theory of regional or agglomerate growth is based on the Krugman assumptions of complete labour mobility, urban population growth with its purchasing power, uniform consumer utility functions, and similar production technologies across regions.

an industrial complex. Venables (1994) has pointed out that endogenous forces dampen the incentive to agglomerate, however, when agglomeration does occur it is associated with wage differentials between locations. These wage differentials discourage industry concentration and encourage a diversified outcome with wage convergence. Ludema and Wooton (1997), and Forslid and Wooton (1999) postulate that, ultimately, agglomerates will be stable because of the forces of comparative advantage and the imperfect mobility of international labour.

In summary, the definition and identification of regional agglomerates facilitates the examination of national manufacturing structures in core regions versus adjacent and periphery regions. Given the classification of regions, and the nature of their input-output production structures, it is not unreasonable to expect that industrial structures of a given core region will have economic linkages with the less developed industrial structures of adjacent regions. The competition effect could lead to economic growth of adjacent regions. However, economic linkages, in the form of manufacturing activity, between a core region and a periphery region can be expected to be weak due to the transport intensity of manufacturing products (Venables and Limao, 2002).

In the face of economic integration the existence of national agglomerates ensures inter-agglomerate trade between them. The trade literature indicates that the core region produces for the local market and for export (Boudeville, 1963; Krugman, 1991b, Davis and Weinstein, 1998). However, with the removal of trade barriers, manufacturers in the core regions have access to potentially new product markets, which, in the first instance, are the densely populated foreign manufacturing core regions. In addition to this, competition will enhance import substitute manufacturing in all regional agglomerates (Krugman and Venables, 1996). Consequently, the composition of regional manufacturing structures will be altered through industry relocation driven by the need for external and internal economies of scale, the dependency on input-output relationships, the need to enhance comparative advantage, and the desire to reduce transportation and trade costs (Forslid *et al.*, 1999).

3.4 A NATIONAL REGIONAL CORE, ADJACENT, PERIPHERY (CAP) MODEL

The objective of this section is to develop a simple three-region model to classify a country's administrative regions into *core regions, adjacent regions*, and *periphery regions*. The significance of the model is threefold. First, it provides a framework for analysing the forces of agglomeration and dispersion at the national regional levels where the shocks of economic integration are initially felt. Second, the model can be easily extended to a multi-region CAP model. Third, the CAP model develops an alternative industry concentration measurement, applicable at the regional level. These three issues are examined in subsequent chapters.

This section is divided into three parts. The first part focuses on the development of a Core, Adjacent, and Periphery (CAP) model. The second part defines the mathematical structure behind the CAP model. The third part explains the criteria, data, and methodology utilised in classifying the national regions. This classification is then used to identify and examine the distribution of these regions throughout the geography of the integrated European market. This allows for the identification of the EU geographic core, the individual EU core regions, the adjacent regions, and the EU geographic periphery.

3.4.1 Development of the CAP Model

The development of the CAP model employs two traditional themes of regional economics. The first, is von Thünen's (1842) concentric circle theory of cultivation. The second, is the theoretical nomenclature used by regional economists ecnomists to describe region types (Paelinck and Nijkamp, 1975). The CAP model is a synthesis of these traditional lines of thought. The CAP model differs from the Venables and Limao's (2002) Heckscher-Ohlin-von Thünen model in a number of ways. One, the CAP model is a national regional model and not a multi-country model. Two, the CAP model is a seamless geographic world of regions and not of 'disconnected' countries. Three, the CAP model assumes interregional labour mobility. Four, the CAP model is a framework for measuring the endogenous forces of economic geography in a world of imperfect competition. The similarites that exist pertain to; one, the inverse relationship between distance from the core and the income received for production activity; and, two, the appropriate analytical framework provided by the CAP model to examine the 'interaction of two types of [region] characteristics with two types of commodity characteristics.'

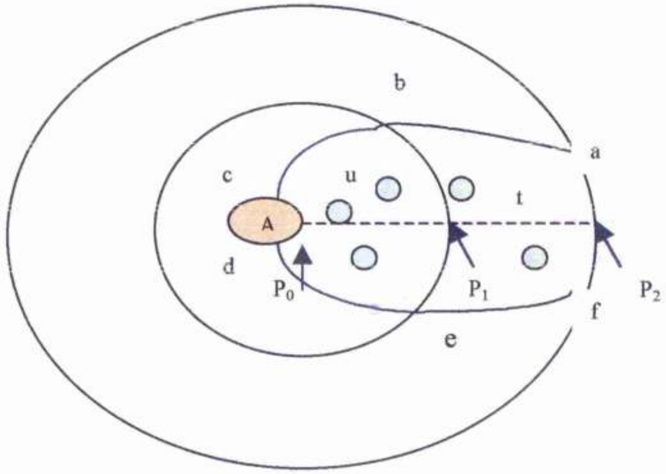
Von Thünen's concentric circle theory of cultivation locates production activity across three geographic areas consisting of: a populated urban area that serves as the consumption and manufacturing core, and a first and second ring of regions where agricultural production is located. Von Thünen illustrated that the transportion costs of market access reduce the level of rental incomes, in direct relation to the distance between the location of production activity and the core region. The further production activity is located away from the core region, the lower will be the level of wages and incomes received.[40]

In Diagram 3.1, the concept of administrative regions is superimposed upon Von Thünen's concentric circle model. The inner circle *A* represents the central urban area. Similarly, P_0P_1 and P_1P_2 respectively respresent the distance of the first and second rings around the core. This defines the concentric circles. The urban area *A* represents an administrative core region. Contiguous to the core region is an area whose administrative boundaries are indicated by *bcde*. This area is an adjacent region which encompases, for example, three urban centres, *u*. This adjacent region falls within the first concentric circle ring. Juxtaposed to the adjacent region is a region, *abef*, which falls in the second concentric circle ring. This region is a periphery region consisting of two small towns, *t*. Jointly these three regions define the CAP model. Distance from the core to the periphery is represented by the radius $P_0P_1P_2$.

[40] Contrary to Venables and Limao (2002), the CAP model assumes all regions are connected.

The CAP model is a domestic regional model where all regions are connected. Labour is mobile between regions and sectors. Product markets exhibit imperfect competition. Given that manufacturing goods are produced with increasing return technology under conditions of imperfect competition, the CAP model facilitates analysis of the forces of agglomeration and dispersion. The home market effect, and its reinforcng price effect, are the two forces that work themselves out in the core region resulting in higher real wages. The competition effect, which resusIts in firm (industry) relocation, works itself out in the first and/or second rings around the core region. This, however, is contingent upon, what will subsequently be referred to as , the firm's (industry's) 'geographic location mix'. The geographic location mix is defined as the firm's (industry's) combination of bearable transportation costs, unexploited economies of scale, and the need for input-output structure in relation to its market – the core region.

DIAGRAM 3.1
RELATIONSHIP BETWEEN CONCENTRIC CIRCLES AND REGIONS



Source: Author's own construct.

The model is significant due to its ability to trace the domestic interregional economic effects of an external shock such as economic integration. The importance of the adjacent region[41] is its distance to the core. Since it is geographically closer to the core than the periphery region, this proximity enhances the attractiveness of the location. Any wage differential, between the core and the adjacent region, increases the attractiveness of this region for industry location, while retaining profitable access to the core region. Centrality is the CAP model's primary focuses, however, at the domestic regional level, the model allows for the identification of one or more national core regions. In addition, it is also readily transformed into a multi-region CAP model. The mathematical development of the following equations is found in Appendix (I) of Chapter 3.

The multi-region CAP model is defined as follows:[42]

$$CAP_j = C_j \cap \sum_{j=1}^{A} A_j \cap \sum_{j=1}^{P} P_j(\theta_{CP} > \theta_{CA} \geq \theta_{AP}) = \varnothing \qquad (3.10)$$

Where, CAP_j represents a core, and a cluster of j adjacent, and periphery regions. These region types are symbolised by: C_j core, A_j adjacent, P_j periphery. Distance from the core is represented by the symbol θ. The expression in brackets states that the distance from the core to the periphery θ_{CP} is greater than the distance from the core to the adjacent θ_{CA}, and the distance from the adjacent to the periphery θ_{AP} is greater than, or equal to the distance from the core to the adjacent. The symbol $\varnothing$ indicates that the regions are non-overlapping.

The multi-region CAP model is called a CAP cluster. The number of first and second ring regions around the core agglomerate determines the number of regions in the cluster. For example, if a core agglomerate is contiguous to one adjacent and one periphery region such that $j = 1$ for both A_j and P_j, this results in a basic three-region CAP cluster. On the other hand, if a core region is surrounded by three adjacent regions and two periphery regions, then $A_j = 3$, and $P_j = 2$, this would provide us with a six-region model, with economic interaction occurring between the regions due to their geographic proximity.

A multi-region country U_i can consist of a number of CAP_j clusters, each with a varying number of regions. An individual country is the sum of its CAP_j clusters, expressed as follows:

$$U_i = \sum_{j=1}^{CAP} CAP_j = \sum_{j=1}^{C} C_j \cap \sum_{j=1}^{A} A_j \cap \sum_{j=1}^{P} P_j(\theta_{CP} > \theta_{CA} \geq \theta_{AP}) = \varnothing \qquad (3.10a)$$

Where, country U_i is the sum of it CAP_j clusters. For example, Spain has the three CAP clusters of Pias Vasco, Madrid, and Cataluna, with each cluster consisting of a different number of regions. This would typify a national multi-agglomerate production structure.

The multi-region CAP model ceases to exist in two cases. First, when the regions in a country do not meet the adjacent and/or periphery region criteria; it is entirely possible that a country consists of a collection of regions where each adjoining region meets the core region criteria. This results in a geographic area of contiguous densely populated regions or agglomerates. An example of this would be the collection of core regions in the German provinces of Baden-Württemberg and Bayern. Second, the

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[41] See sections (d) of Diagrams 2.8 and 2.9 of the Forslid *et. al.*,(1999) paper that pertain to industry relocation. In the analysis firms relocate either from the outer core to the inner core or vice-versa and from the core to the periphery. An adjacent region or country eliminates this gap.

[42] Equation (3.10) is developed from equation (3.9) in Appendix I, Chapter 3. Each CAP cluster is a union of administrative regions around a core region that form a non-overlapping collective.

model is not applicable when a country has no periphery regions. In this instance the adjacent region would become the growth region, as would be the case in Belgium.

The core regions within a country represent a central geographic location of concentrated production activity. These regions attract or disperse economic activity. If the core is an attraction region, the agglomeration forces pull economic activity from the adjacent and the periphery regions, to the core as a result of higher wages. Conversely, if the core is a dispersion region, the competition effect will push economic activity in the opposite direction. That is, if the cost of production in the adjacent and periphery regions is relatively lower than in the core region i.e. a wage differential, the core becomes a dispersion region.

The CAP model postulates that the pre-integration regions in the CAP clusters are not symmetrical. In other words, manufacturing is not equally distributed over the regions, but instead the CAP model indicates a sequentially declining manufacturing concentration from the core to the periphery. The model also assumes, by definition of the regions, that the regional concentration of agricultural production is the inverse of manufacturing concentration. This means that agricultural imports to the core are subject to transportation costs. This indicates an upward sloping factor input supply curve that will eventually mitigate the forces of agglomeration in the core regions (Krugman and Venables, 1990).

The dynamics released by the forces of economic integration would initially impact the core agglomerates, and from there, they would spread to the lower cost adjacent regions, and into the periphery regions. It affects a firm's (industry's) geographic location mix. Together with an improved domestic infrastructure, reduced transportation costs, would encourage the relocation of firms away from the core that are: i) not dependent on strong input-output structures, ii) and/or have low demand elasticities, iii) and/or wish to relocate to lower cost regions, to enhance their comparative advantage position. In the case of labour intensive industries, the impact of these dynamics is more pronounced.

3.4.2 Data, Criteria, and Methodology

Data

The source of the data used for the analysis of the EU regions was the Eurostat (1993) publication '*Portrait of the Regions*', Vol. 1 – 4. This publication provided the most uniform data for the EU 15 Member States. However, the data is not completely uniform across all regions for a number of reasons: German Unification was completed in October 1990, and Finland, Austria, and Sweden were admitted to the EU in 1995. For the former East German Länder, the data was supplemented by information from the European Commission publication, (1994), 'EC Regional Policies, Competitiveness and Cohesion', while various Eurostat publications 'REGIONS - Statistical Yearbook' have provided missing data for the other countries. The regions of all Member States have an identification code at the NUTS 1, NUTS 2, and

NUTS 3 levels.[43] Although the regions of Ireland have a NUTS 2 code, the regional data is not published on a consistent basis. The same is true for Denmark. This study employs regional data at the NUT 2 level for 1989 and 1990.

The publication, '*Portrait of the Regions*', provides information on geographic, demographic, and economic variables. Data pertaining to these variables was available on the provincial, regional, and county levels. Each region is subdivided into its counties. The county level provides information on the urban areas in each county, and thus the region in its totality. In each administrative NUTS 2 region the number of urban centres are classified by total population categories of one hundred thousand or greater, fifty thousand or greater, and twenty thousand or greater. This information facilitates the identification of the major urban centres in a region. The urban population density per square kilometre statistic is provided for each major city in an administrative region. The regional population statistic– population per square kilometre – is a population density measure for each county in the region, and the region in its totality. It includes the population in urban and rural districts.[44]

Classification Criteria

In the Labour Force Survey of 1998, Eurostat[45] introduced the concept of urbanisation and urban areas for each region. Three types of regions are defined according to their degree of urbanisation. Although they have been somewhat modified, this analysis has made use of these definitions. A *densely* populated region is one where one or more urban areas have a population density of more than 500 people per square kilometre. The region may also contain other urban areas with a lower population density. An *intermediate* region is one that is composed of one or more urban areas with a population density of more than 100 people per square kilometre, [but less than 500 per square kilometre, and borders on a densely populated region].[46] A region with a *low* population density is characterised as having less than 100 people per square kilometre and does not border on an intermediate area. However, this analysis will not make use of the Eurostat definition of a low population region. Alternatively, any region that does not border on a densely populated region, but only on an intermediate region, will be referred to as a periphery region. A low population density region, as defined by Eurostat, can only be assumed to be an island region.

This study uses the following regional definitions for classification purposes. A *core region* is defined as a region with one or more urban areas with a population density greater than 500 people per square kilometre. Such an urban area is called an urban *agglomerate*.[47] The term, *adjacent region,* refers

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[43] NUTS is Eurostat's acronym for 'Nomenclature of Territorial Units for Statistics'.

[44] The author has developed a database containing geographic, demographic, and economic data at the NUTS 1, NUTS 2, and NUTS 3 regional classification levels.

[45] Eurostat, *Statistics in Focus: Regions, 1998 (4)*

[46] Author's insertion and modification.

[47] Eurostat definition.

to those regions, which border on core regions, and that have one or more urban areas with a population density greater than 100 people, but less than 500 / km^2. Finally, a *periphery region* is a region bordering only on an adjacent region or another periphery region. Furthermore, a periphery region can have one or more urban areas with a population density greater or less than 100 people per square kilometre.

Methodology

The CAP model has postulated that a core region can be surrounded by a first-ring of adjacent regions, and a second-ring of periphery regions. The number of adjacent and periphery regions in a cluster can vary depending on the dispersion and density of urban agglomerates. A *CAP* cluster j is defined in equation (3.10) as follows:

$$CAP_j = C_j \cap \sum_{j=1}^{A} A_j \cap \sum_{j=1}^{P} P_j(\theta_{CP} > \theta_{CA} \geq \theta_{AP}) = \varnothing \qquad (3.10)$$

To obtain a three-region CAP model, this analysis assumes that $j = 1$, and rewrite equation (3.10) to include the theoretical regional criteria as follows:

$$CAP_1 = \varphi(upd_i) \in C_1 \cap \gamma(upd_i) \in A_1 \cap \gamma(upd_i) \in P_1(\theta_{CP} > \theta_{CA} \geq \theta_{AP}) = \varnothing \qquad (3.11)$$

This expression (3.11) defines a three-region *CAP* model consisting of one core, one adjacent, and one periphery region. The hierarchical link between the regions is determined by the population density and distance criteria. The subscripts i refer to the number of urban areas in the respective regions.

The classification procedure used the urban population density of cities in the administrative regions. The regions were then classified into core, adjacent, and periphery based on the urban population and the distance criteria. These are listed in Table 3B.1 in the Appendix 3B to Chapter 3. There are six types of core regions, four types of adjacent regions, four types of periphery regions, and four types of island periphery regions. The major classifications of core, adjacent, and periphery have been subcategorised. The region types are identified by the symbols $R(x,y)$, where R refers to region type: C, A, P, and IP, x indicates the regions population criterion, and y represents the number of urban areas in the region that meets the required criterion. The classification of methods and the symbols used is described in detail in Appendix 3B of Chapter 3, as are the regional classification results.

3.5 THE CLASSIFICATION AND DISTRIBUTION OF THE EU REGIONS

The objective of this section is to classify the administrative regions into core, adjacent, and periphery regions, and to examine their distribution throughout the countries of the EU. The significance of the classification of the regions lies in the subsequent ability to identify and compare industry location and concentration before and after the complete removal of trade barriers in 1992. Unification encourages the former border periphery regions to establish interindustry and interregional economic linkages to stimulate their economic development. As such, the creation of an integrated geographic market results in a reclassification of the border periphery regions contiguous to foreign core regions.

This section focuses on regional classification, rather than on the comparison of interregional industry concentration. The former analysis must precede the latter, which becomes a topic for subsequent research. [48] The analysis in this section yields answers to several key questions. First, how many CAP regions are there in each individual member state? The answer to this query will reveal the number of CAP regions in each country, and the change in the classification of periphery regions to adjacent regions as a result of unification. Second, this analysis affords us the opportunity to study the location and distribution of the regions in geographic space in order to determine the classification of regions positioned in the EU geographic periphery. Third, it allows for the exact identification of the EU geographic core, as well as the independent core agglomerates that signify a multi-agglomerate production structure (Krugman, 1991a)

The preliminary stylised facts indicate that the fifteen EU member states consist of 81 provinces, 222 regions, and 874 counties, including the regions of Denmark and Ireland, but excluding the French Dependencies. The integrated market has a total of 2,449 urban centres, of which 355 each have a total population greater than 100,000 inhabitants, 509 each with a total population greater than 50,000 inhabitants, and 1,585 with a population greater than 20,000 inhabitants. However, urban areas with a population less than 20.000 are not included in the above total.

The results of classifying the national regions into core, adjacent, and periphery are found in Table 3.1. The periphery regions have been subdivided into continental and island periphery regions. The Irish and Danish regions are included.

The classification results reveal five salient points. One, Belgium has no periphery regions, while Denmark is a predominantly peripheral area. Two, Germany has 29 core regions and two periphery regions. Three, France consists of one core region and 15 periphery regions. Four, Greece, Ireland, Austria, Finland and Sweden respectively have only one core region. Five, the countries with the highest relative number of core regions are the UK, Belgium, the Netherlands, Germany, and Italy. There is some change in regional classification after EU integration in 1992. This consists primarily of the change of border periphery regions into adjacent regions.

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[48] Core regions are agglomerates. These agglomerates are distributed throughout the individual EU countries. Identifying their location contributes significantly to the analysis of industry concentration in the EU. Furthermore, it facilitates the EU interregional comparison of regional industry structures, concentration, and specialisation.

TABLE 3.1

EU 15 REGIONAL CLASSIFICATION 1990

(1)	(2)	(3)	(4)	(5)	(6)	(7)
N	Country	C	A	P	IP	Total
1	Belgium	6	5			11
2	Denmark	1	3	9	1	14
3	Germany	29	7	2		38
4	Greece	1	2	6	4	13
5	Spain	4	7	5	2	18
6	France	1	5	15	1	22
7	Ireland	1	3	4		8
8	Italy	5	11	2	2	20
9	Luxembourg		1			1
10	Netherlands	5	4	3		12
11	Austria	1	1	7		9
12	Portugal	2	2	1	2	7
13	Finland	1	1	3	1	6
14	Sweden	1	1	6		8
15	UK	14	16	5		35
	Total	72	69	68	13	222

Source: Author's own calculation.

To address the issue of how the classification of regions changed after the removal of trade barriers, i.e. Europe 1992, a more detailed overview of the regional classification is necessary. Although the information in Table 3.1 provides a comprehensive overview of regional classification, Table 3.2 presents a more detailed view that considers the urban population density criteria. Table 3.2 represents the regional classification of a *segmented* Europe, as was the case before the signing of the Maastricht Treaty of 1992. The column numbers of Table 3.2 correspond to those of Table 3.1.

TABLE 3.2

DETAILED EU 15 REGION CLASSIFICATION 1990

(1)	(2)							(3)					(4)					(5)					(6)	(7)
N	Country	C	C1	C2	C3	C4	C5	TC	A	A1	A2	A3	TA	P1	P2	P3	P4	TP	IP1	IP2	IP3	IP4	TPI	Total
1	Belgium	1				5		6	1	4			5					0						11
2	Denmark				1			1		2	1		3	3	6			9		1			1	14
3	Germany	3		12	10	4		29	1	5	1		7	2				2						38
4	Greece					1		1			2		2	1	4	1		6	2	2			4	13
5	Spain	1		1		2		4		2	3	2	7	3	1	1		5	2				2	18
6	France	1						1		2	3		5	12	3			15				1	1	22
7	Ireland						1	1			1	2	3			4		4						8
8	Italy			1	2	2		5		7	4		11	1		1		2	2				2	20
9	Luxembourg							0		1			1					0						1
10	Netherlands	1		1	1	2		5		4			4	3				3						12
11	Austria	1						1	1				1	6		1		7						9
12	Portugal				2			2		1		1	2		1			1	2				2	7
13	Finland						1	1				1	1			1	2	3				1	1	6
14	Sweden						1	1				1	1	2		1	3	6						8
15	UK	1	3	1	1	7	1	14		14	2		16	3	1		1	5						35
	Total	9	3	16	17	23	4	72	3	42	17	7	69	36	16	10	6	68	8	3	0	2	13	222

Source: Authors own calculations.

3.5.1 Core Regions

Europe is comprised of seventy-two core regions, varying in population density and number of urban areas. Of these, nine are single city core regions (*C*). Three of these single city core regions are located in Germany. The UK has three multiple city core regions (*C1*). There are sixteen core regions (*C2*) with urban areas whose population density exceeds 2,000 people per square kilometre, of which twelve are located in Germany. Germany also has the most (*C3*) core regions with an urban population density that exceeds 1,000 people per square kilometre. A third of the total core region consists of regions with urban agglomerates (*C4*) of 500 or more, but less than 1,000 people per square kilometre; seven of these are found in the UK, five in Belgium and four in Germany. There are four (*C5*) core regions with urban agglomerate whose population density is less than 500 people per square kilometre. These agglomerates are found in Ireland, Northern Ireland, Finland, and Sweden.

3.5.2 Adjacent Regions

There are a total of sixty-nine adjacent regions in the individual countries that form the first order contiguity circle of regions.[49] There are three adjacent regions, (*A*), that surround a core region. This type of region is characterised by towns and cities with a very low (< $20/km^2$) population density, where the core region attracts all economic activity. For example; in Belgium, Vlaams-Brabant surrounds Brussels; in Germany, the region of Brandenburg surrounds the core city-region of Berlin; and in Austria, the region of Niederösterrech surrounds the region of Vienna. Of the sixty-nine adjacent regions, forty-two have urban agglomerates (*A1*) with a population density between 100 and 499 people per square kilometre. The UK dominates this category with fourteen such regions, followed by Italy with seven and Belgium with four. There are seventeen adjacent regions (*A2*), with urban centres where the population density lies between 50 and 99 people per square kilometre. Finally, the data revealed seven adjacent regions (*A3*) with one or more urban areas, each with population densities less than 50,000.

3.5.3 Periphery Regions

In the geographic region of Europe, there are eighty-one periphery regions subdivided into sixty-eight continental and thirteen island periphery regions. Of the sixty-eight continental periphery regions (*P1*) that border on an adjacent region, more than half have urban areas with a population density greater than 100, but less 500 people per square kilometre. France dominates this category with twelve such regions, followed by Austria with half as many. Of Denmark's six periphery regions (*P2*), one or more urban centres have a population density exceeding 50, but less than 100 people per square kilometre. Of the ten (*P3*) periphery regions, with an urban population density great than 20 but less than 50 thousand people per square kilometre, four are found in Ireland. Finally, the six (*P4*) periphery regions, with urban population densities less than 20 thousand people per square kilometre, consist of the two adjacent periphery regions of Ita-Suomi and Pohjois-Suomi in Northern Finland, the three adjacent peripheral regions of Norra Mellansverige, Mellersta Norrland, and Övre Norrland, that stretch into Northern

[49] The term 'first-order contiguity' refers to the first concentric circle around the core region.

Sweden; and the Scottish Highlands and the Islands in the UK. It is significant to note that in pre-integrated Europe, France had the largest number of periphery regions in the EU Since periphery regions are predominantly agricultural, this geographic fact influences France's bargaining position in the Common Agricultural Policy discussions.

3.5.4 *Island Periphery Regions*

In total, there are thirteen peripheral-island-regions under EU administration. Of these, eight have urban centres (*IP*1) with total populations of 100,000 or more. The second set of peripheral-island-regions (*IP*2) is primarily composed of the Grecian Islands of Voreio Aigaio and Notio Aigaio. Of these two, the former has two urban centres with a total population of 50,000 or more, while the latter has only one. Finally, both Finland and France have a peripheral island region in the (*IP*4) category. The French island of Corsica has two urban centres, each with a total population less than 20,000. In contrast to this, the Finish peripheral island region of Åland, on the other hand, which lies halfway between Finland and Sweden, does not have an urban centre at all.

3.6 EU GEOGRAPHY POST 1992

Europe 1992 desegmented the European markets by removing non-tariff barriers. Table 3.3 shows the reclassification of periphery regions into adjacent regions after the removal of these barriers. The reclassification pertains to those member state's peripheral-border-regions that border on foreign core regions before the removal of trade barriers.

TABLE 3.3

DETAILED EU 15 REGIONAL RE-CLASSIFICATION 1997

(1)	(2)							(3)					(4)					(5)					(6)	(7)
N	Country	C	C1	C2	C3	C4	C5	TC	A	A1	A2	A3	TA	P1	P2	P3	P4	TP	IP1	IP2	IP3	IP4	TIP	Total
1	Belgium	1				5		6	1	4			5											11
2	Denmark				1			1		2	2		4	3	5			8		1			1	14
3	Germany	3		12	10	4		29	1	5	1		7	2				2						38
4	Greece					1		1			2		2	1	4	1		6	2	2			4	13
5	Spain	1		1		2		4		3	3	2	8	2	1	1		4	2				2	18
6	France	1						1		9	3		12	5	3			8				1	1	22
7	Ireland						1	1			1	3	4			3		3						8
8	Italy			1	2	2		5		7	4		11	1		1		2	2				2	20
9	Luxembourg							0		1			1											1
10	Netherlands	1		1	1	2		5		6			6	1				1						12
11	Austria	1						1	1	5			6	1		1		2						9
12	Portugal				2			2		1		1	2		1			1	2				2	7
13	Finland						1	1				1	1			1	2	3				1	1	6
14	Sweden						1	1		1		1	2	1		1	3	5						8
15	UK	1	3	1	1	7	1	14		14	2		16	3	1		1	5						35
	Total	9	3	16	17	23	4	72	3	58	18	8	87	20	15	9	6	50	8	3	0	2	13	222

Source: Author's own calculations.

Without these trade barriers, such periphery regions fall into the first concentric circle of the foreign core region, thereby changing their classification to that of an adjacent region by virtue of the concentric circle definition of regions. Their connectivity[50] to a foreign core region encourages the spread of economic linkages. These regions can now evolve into growth regions, since they provide an expansion path for industry wishing to relocate out of the core. Alternatively, the regions become target regions for new firms wishing to locate close to a core region. Reclassification has resulted in the creation of eighteen new adjacent regions, and the elimination of an equal number of periphery regions. Furthermore, the number of adjacent regions has increased from sixty-nine to eighty-seven, with the major additions occurring in the $(A1)$ category.

The major beneficiary of the reclassification has been France, where the status of seven of its twelve periphery regions changed, as a result of their contiguity to the core regions of Belgium, Spain, Germany, and Italy. In the other EU member states, the following changes from periphery to adjacent regions took place. In Denmark, the region of Sønderjylland became an adjacent region to the German core region of Schleswig-Holstein. In Spain, Galicia changed status, since it borders on the Portuguese core region of Norte. Similarly, in Ireland, the region of the Northwest and Donegal now borders on the core region of Northern Ireland. In the Netherlands, the two periphery regions of Groningen and Drenthe border on the German core region of Weser-Ems. In Austria, integration reduced six periphery regions to one. Specifically, the Austrian regions of Voralberg, Tirol, Salzburg, and Oberösterreich now border on the core regions of the German province of Bayern, and Kärnten borders on the Italian core region of Friuli-Venezia Giulia. Finally, in Sweden the periphery region of Sydsverige borders on and is connected by bridge to the Danish core region of Copenhagen. Each of these instances highlights the relationship between the removal of trade barriers and the reclassification of these regions.

Integration has left the number of core regions, and the number of periphery island-regions, unchanged. In other words, only the number of adjacent regions has been increased. No reclassification of regions occurred in Belgium, Luxembourg, Germany, Greece, Italy, Portugal, Finland, or the UK. The most salient effect of integration and reclassification has been the transformation of the Austrian regions from periphery into adjacent regions. Its significance lies in the fact that these regions form part of the EU geographic core, which consists primarily of contiguous core regions, with adjacent regions serving as buffer regions between them. The reclassification is significant for the analysis of industry relocation and the creation of possible new input-output structures in the former periphery regions. It is not unreasonable to expect income growth in these newly classified regions.

3.6.1 The Geographical Distribution of the Regions

The second classification issue pertains to the question of how the regions are distributed in geographic space. It is of interest to know the location and distribution of the regions not only per

[50] Given the similarity in the population density elements in the subsets A and P, as specified by equations (3.4a) and (3.12), a periphery region's connectivity to a core region eliminates the distance criterion from the equations for these regions. Therefore, by virtue of the similarity in the subset criterion elements, the periphery regions are respectively classified into adjacent regions.

individual member state, but also for the geographic market in its totality. This is relevant since not all border regions are by definition periphery regions (Brülhart and Torstensson, 1996). In Table 3.4, the regions have been categorised according to the criteria of their geographic location.

The Single City Regions meet the dual criteria of: one, official classification, and, two, the absence of agricultural employment. The *Interior Non-Border / Coastal Regions* are regions that do not have a coastline or border on an EU or non-EU State. The *Non-Coast Borders on Member EU State* are those regions without a coastline that border on a pre-integration foreign region. The second group of border-regions is the *Non-Coast: Borders on Non-EU Country*. These regions border on the former East European Countries. The final group on the EU continent is the *Regions with a Coastline*. The *Island Regions* are removed from the continent.

TABLE 3.4

GEOGRAPHIC DISTRIBUTION OF THE REGIONS

Nr.	Country	Single City Regions	Interior Non-border / Coastal Regions	Non-Coast Borders Member EU State	Non-Coast Borders Non-EU Country	Regions with a Coast-line: Total	Regions with a Coast-line: Bordering on: EU State	Regions with a Coast-line: Bordering on: Non EU States	Island Regions	Total Country Regions
	Euro 15	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	Belgium	1	3	7		1	2			11
2	Denmark			1		13			1	14
3	Germany	3	17	12	6	5	2	1		38
4	Greece		1		1	8		3	4	13
5	Spain	2	3	4		9	4	1	2	18
6	France	1	5	5	3	10	5		1	22
7	Ireland			1		7				8
8	Italy		1	3	4	13	1	1	2	20
9	Luxembourg		1	1						1
10	Netherlands	1	1	5		6	2			12
11	Austria	1		5	7					9
12	Portugal					5	4		2	7
13	Finland				1	4		3	1	6
14	Sweden					8		4		8
15	United kingdom	6	11			24				35
	Total Regions	15	43	44	22	113	20	13	13	222
Average (Y/P) PPS 1990		118.8	103.3	102.5	96.4	87.6			65.8	92.3
Average (Y/P) PPS 1997		120.7	104.6	104.5	100.1	89.7			71.7	95.3

Source: Authors own calculations.

The significance of this distribution pertains primarily to the border and coastal regions listed in columns (3), (4), and (5). The analysis indicates that each of these clusters of border and coastal regions contain core, adjacent, and periphery regions. Because a particular region may qualify for both categorisations, the above distribution contains some double counting. The *Non-Coastal: Bordering on a Member State* group contains eighteen core, and twenty-two adjacent regions respectively. The cluster *Non-Coastal: Bordering on a Non-EU-Country* contains six core regions and five adjacent regions. Finally, the group *Regions with a Coastline* shows twenty-eight core regions, thirty-five adjacent regions, and fifty periphery regions. These three clusters demonstrate that a region's geographic location does not pre-determine its classification type.

3.6.2 Urban Agglomerates and the EU Geographic Core

This section examines the concept of the EU geographic core (Krugman and Venables, 1990) and answers the question; 'How many adjoining core regions form the EU geographic core, and where are they located?'

The EU geographic core is formed by fifty-two of the seventy-two core regions of its member states. In addition to this, there are fourteen individual adjacent regions serving as buffers between the major core clusters. The geographic core stretches in an arc through continental Europe creating a north – south divide. As shown in Table 3.5, it finds its beginning on the Western UK coast, with the cluster of adjoining core regions consisting of Merryside, Greater Manchester, and west and south Yorkshire. The multiple urban core region of West Midlands is surrounded by adjacent regions; however, it leads to the largest UK cluster of adjacent core regions with Greater London as its turning point to the South. The adjacent region of Kent serves as the UK thoroughfare to the core regions of the European continent. On the continent, the core regions of the Netherlands and Belgium provide a manufacturing location continuum with the manufacturing structure in western Germany.

The only French core region of Ile-De-France is connected in the North via Namur to the Belgian cluster of core regions via the geographic location of the French adjacent regions of Picardi and Champagne-Ardenne. Although Ile-De-France is an offshoot of the contiguous adjoining geographic core regions, it and its surrounding adjacent Northeastern and Northwestern core regions of the Basin Parisian flank the Southern regions of the geographic core. Furthermore, they serve as a thoroughfare from the UK to the southwestern German core regions.

The European geographic core finds its largest concentration in the adjoining core regions located in the six western, southwestern, and southern German provinces. In the west, the cluster of Dutch geographic core regions extends into the German Province of Nordrhein-Westfalen, with the core region of Düsseldorf as its centre. From Nordrhein-Westfalen, the geographic core extends north into the Province of Niedersachsen, and east into the Province of Hessen. The province of Rheinland-Pfalz borders on the two provinces of Saarland and Baden-Württemberg. All the regions in these two provinces are adjoining core regions. To the East of Baden-Württemberg lies the southern German Province of Bayern, with its cluster of adjoining core regions, which extend to the northern border of Austria. Of the fifty-two core regions that form the EU geographic core, Germany contributes a geographic continuum of twenty-five core regions, which constitutes 48% of the geographic core. Since Düsseldorf, in Germany, is a core region with five urban agglomerates each with a population density greater than 2,000 per square kilometre, this region is assumed to be the centre of the geographic core.

The corridor of the east - west Austrian adjacent regions of Kärnten, Salzburg, and Tirol, function as thoroughfares from the eastern and western core regions of Bayern, and the entire geographic core, into Northern Italy. The southern extremity of the EU geographic core is found in the northern regions of Italy.

TABLE 3.5
THE EU 15 GEOGRAPHIC CORE

K	PROVINCE	N	Code	Regions	d	Core Reg 1997	Reg. Pop. Dens 1997	Nr Urb Ar.	Tot. Pop. Change 90-97	Y/P (PPS) 1990	Y/P (PPS) 1997	90-97	Unemployment U (%) 1990	Unemployment U (%) 1997	Unemployment 90-97
K1	NORTH - WEST	1	UK84	Merryside	931	C1	2166.3	9	-24.6	77	74.6	-2.4	12.6	10.3	-2.3
		2	UK82	Greater Manchester	855	C1	2004.9	10	-12.9	92	93.2	1.2	7.9	7.4	-0.5
K2	YORKSHIRE-HUMBERSIDE	3	UK24	West Yorkshire	898	C3:1	1038.9	6	43.4	95	93.8	-1.2	6.8	7.1	0.3
		4	UK23	South Yorkshire	847	C4:1	838.1	4	10.9	80	75.4	-4.6	9.3	10.4	1.1
		5	UK31	Derbyshire, Nottinghamshire	783	A1:2	417.5	13	49.2	92	93.1	1.1	6.1	6.8	0.7
		6	UK72	Shropshire, Staffordshire	828	A1:2	239.1	11	37.2	86	89.0	3.0	4.4	6.1	1.7
K3	WEST - MIDLANDS	7	UK73	West Midlands	774	C1	2938.8	6	26.1	97	94.4	-2.6	8.4	8.8	0.4
		8	UK71	Hereford-Worcs., Warwick	726	A1:2	203.9	9	44.4	89	101.0	12.0	3.8	4.5	0.7
		9	UK32	Leic., Northamptonshire	735	A1:2	312.8	11	60.3	107	105.5	-1.5	4.0	4.2	0.2
K4	WALES	10	UK92	Gwent,Mid-S-W-Glamoran	819	C4:2		16		82	73.9	-8.1	7.2	7.8	0.6
	SOUTH-EAST-WEST (UK)	11	UK61	Avon,Glouch, Wilshire	760	C4:1	282.3	11	101.4	108	114.8	6.8	3.9	5.4	1.5
		12	UK52	Berks,Bucks,Oxfords	639	C4:1	362.2	12	95.6	113	126.3	13.3	2.2	4.3	2.1
		13	UK51	Bed-,Herfordshire	658	C4:1	547.4	13	49.7	105	104.5	-0.5	2.7	4.7	2.0
		14	UK55	Greater London	570	C	4489.7	1	316.3	154	145.7	-8.3	6.3	9.5	3.2
		15	UK53	Surrey, East-West Sussex	626	C4:1	464.5	18	116.4	101	106.7	5.7	2.4	4.4	2.0
		16	UK57	Kent	472	A1:1	418.8	18	38.2	92	93.7	1.7	3.9	6.3	2.4
K5	NETHERLAND	17	NL32	Noord-Holland	238	C3:5	932.8	22	104.4	118	127.6	9.6	7.4	5.7	-1.7
		18	NL33	Zuid-Holland	230	C2:1	1169.1	33	131.8	109	116.7	7.7	7.3	5.2	-2.1
		19	NL31	Utrecht	179	C	794.9	12	67.8	95	125.6	30.6	6.2	4.0	-2.2
		20	NL22	Gelderland	123	C4:1	379.1	27	87.3	87	100.5	13.5	7.2	4.4	-2.8
		21	NL41	Noord Brabant	111	A1:4	468.7	26	122.9	95	114.6	19.6	6.6	4.5	-2.1
K6	BELGIUM	22	BE21	Antwerpen	212	C4:2	570.8	16	39.7	166	169.1	3.1	6.5	7.3	0.8
		23	BE1	Brussels	252	C	5897.7	1	-12.1	126	138.5	12.5	9.9	13.5	3.6
		24	BE23	Oost Vlaanderen	283	C4:3	454.8	17	24.3	100	104.1	4.1	5.5	6.6	1.1
		25	BE25	West Vlaanderen	274	C4:1	358.7	14	21.3	107	116.2	9.2	3.7	5.2	1.5
		26	BE32	Hainaut	169	C4:2	339.1	17	5.7	78	79.0	1.0	13.1	15.4	2.3
		27	FR21	Champagne-Ardenne	287	A2:2	52.8	8	4.0	112	90.1	-21.9	9.3	13.3	4.0
K7	FRANCE	28	FR1	Ile de France	487	C	921.8	37	421.8	166	152.6	-13.4	8.7	10.8	2.1
		29	BE35	Namuur	137	A1:1	119.5	3	17.1	83	86.0	3.0	9.9	11.3	1.4
K8	BELGIUM / NETHERLAND	30	BE33	Liege	121	C4:1	263.0	10	17.8	96	98.6	2.6	11	12.2	1.2
		31	NL42	Limburg (NL)	110	C4:1	524.4	13	33.1	94	103.1	9.1	7.2	5.7	-1.5
K9	NORDRHEIN-WESTFALEN	32	DEA1	Dusseldorf	0	C2:5	996.2	42	101.2	124	115.5	-8.5	7.3	9.6	2.3
		33	DEA2	Koln	40	C2:2	568.8	53	226.1	114	115.3	1.3	6.5	8.3	1.8
		34	DEA3	Munster	136	C2:1	376.6	29	162.2	96	96.5	0.5	7.2	8.6	1.4
		35	DEA4	Detmold	150	C3:1	313.2	21	191.5	107	102.1	-4.9	5.6	8.4	2.8
		36	DEA5	Arnsburg	45	C2:3	476.8	40	130.5	105	99.8	-5.2	7.3	9.7	2.4
K10	RHEINLAND-PFALZ	37	DEB1	Koblenz	153	C3:1	187.3	6	134.9	95	89.7	-5.3	4.5	6.8	2.3
		38	DEB2	Trier	278	C4:1	103.7	1	32.5	89	93.2	4.2	5.1	6.3	1.2
		39	DEB3	Rheinessen-Pflaz	287	C2:1	292.2	12	155.1	114	100.9	-13.1	4.3	7.7	3.4
K11	SAARLAND	40	DEC	Saarland	348	C4:2	418.0	13	9.3	109	98.3	-10.7	7.2	10.2	3.0
K12	HESSEN	41	DE71	Darmstadt	217	C2:2	497.4	31	212.1	158	164.7	6.7	3.5	6.7	3.2
		42	DE73	Kassel	225	C3:1	153.4	7	83.5	104	105.9	1.9	5.8	9.1	3.3
K13	BADEN - WURTEMBURG	43	DE11	Stuttgart	392	C2:1	369.4	33	290.1	137	130.5	-6.5	2.7	6.1	3.4
		44	DE12	Karlsruhe	284	C2:1	385.3	20	181.9	123	134.1	11.1	3.7	6.6	2.9
		45	DE13	Freiburg	477	C3:1	226.0	17	179.9	109	106.2	-2.8	2.8	6.3	3.5
		46	DE14	Tubingen	517	C4:1	195.9	13	157	112	110.1	-1.9	2.8	5.7	2.9
K14	NIEDERSACHSEN	47	DE91	Braunschweig	246	C3:1	206.2	16	55.7	111	97.6	-13.4	7.8	11.4	3.6
		48	DE92	Hannover	250	C2:1	237.5	23	116.3	115	111.4	-3.6	6.8	9.1	2.3
		49	DE94	Wesser-Ems	404	C3:3	160.5	23	231.9	93	102.2	9.2	6.6	9.3	2.7
K15	BAYERN	50	DE26	Unterfranken	363	C3:3	1559.0	4	94.7	98	102.1	4.1	3.6	6.5	2.9
		51	DE27	Schwaben	555	C3:1	173.8	8	142.6	110	105.4	-4.6	2.8	5.9	3.1
		52	DE25	Mittlefranken	452	C2:1	231.7	8	112.7	125	121.3	-3.7	3.8	7.2	3.4
		53	DE24	Oberfranken	417	C3:2	154.1	7	58.1	103	106.4	3.4	4.1	7.4	3.3
		54	DE23	Oberplaz	542	C3:1	110.3	6	78.1	94	96.8	2.8	4.6	6.5	1.9
		55	DE22	Niederbayern	596	C4:3	112.6	4	106.1	95	101.4	6.4	3.6	5.6	2.0
		56	DE21	Oberbayern	620	C2:1	228.0	14	275.7	146	164.7	18.7	2.8	4.8	2.0
		57	AT32	Salzburg	759	A1:1	71.5	1	29.6	118	122.6	4.6	2.9	3.9	1.0
		58	AT33	Tirol	757	A1:1	52.3	1	30.5	107	106.7	-0.3	2.9	5.4	2.5
		59	AT21	Kamten	847	A1:1	59.1	2	15.4	85	89.0	4.0	3.9	5.7	1.8
		60	IT31	Trentino-Alto Adage	927	A2:2	67.7	3	34.2	135	131.1	-3.9	2.7	4.1	1.4
K16	NORTHERN - ITALY	61	IT33	Friuli-Venezia Giulia	1193	C3:1	151.1	5	-17.8	122	125.1	3.1	5.7	7.0	1.3
		62	IT32	Venetio	989	A1:6	242.9	26	75.8	117	123.0	6.0	3.9	5.3	1.4
		63	IT20	Lombardia	876	C3:1	375.9	52	61.5	135	131.1	-3.9	3.4	6.0	2.6
		64	IT11	Piemonte	936	A1:5	169.0	30	-65.6	121	116.7	-4.3	6.0	8.6	2.6
		65	IT13	Liguria	1015	C4:1	303.8	11	-81.0	116	118.9	2.9	8.5	11.5	3.0
				Total of the Geographic Core Regions		51		844	5640.8	108.4	109.91		5.8	7.4	
				Total of Geographic Core-, & Adjacent		65		1006							

Source : Author's own research. Data from Eurostat.

In contrast to the other EU states that form a part of this geographic core, Italy does not have a cluster of adjoining core regions. Instead, northern Italy contains three core regions, each separated from the other by an adjacent region. For instance, in the Northeast, the core region of Liguria is separated from the core region Lombardia by the adjacent region of Piemonte, while in the northwest the core region of Friuli-Venezia Giulia is separated from Lombardia by the adjacent region of Veneto.

It can be concluded that the EU manufacturing belt consists primarily of the core regions in those countries that signed the Treaty of Rome in 1957. Since that time, the manufacturing belt was extended to include the UK, with its densely populated manufacturing regions. As a result of that development, the continental manufacturing belt evolved into its current characteristic banana shape.

Identifying the geographic core is significant because it highlights the EU's largest population density continuum. The new trade theory posits that manufacturing locates in proximity to its final markets. The classification of the composite core regions of the geographic core allows us to study the industrial complexes in these regions. Alterations and developments in their size and composition will provide key indicators, which can be utilised to assess the degree to which economic integration has induced manufacturing to relocate to the EU geographic core or to disperse away from it (Midelfart *et. al.*, 2000).

3.6.3 Urban Agglomerates Outside the EU Geographic Core

The EU geographic core creates a north-south divide of the European economic market with twenty independent urban agglomerates located in the northern and southern regions. The issue of the independent agglomerates is meaningful because of the theory surrounding their stability. This question will be addressed in a subsequent chapter, in which the issue of the changing composition of individual industrial complexes due to integration will be examined. The independent agglomerate-regions are listed in Table 3.6.

Table 3.6 illustrates that the urban agglomerates of Bremen, Hamburg, and Berlin lie immediately north of the geographic core, as does the urban agglomerate of Kiel in Schleswig-Holstein. In Denmark lies the core region of Copenhagen, which serves as a conduit to Sweden and its core region of Stockholm. The core region of Uusimaa in Finland with Helsinki as its capital is the most northern EU core region. The core regions of Stockholm and Uusimaa are exceptions to the definition of urban agglomerates as applied to the other EU regions.

In the northern UK, the contiguous core regions of Northumberland-Tyne & Wear and Cleveland- Durham form a cluster of core regions quite far removed from the centre of the geographic core. To the northwest lie the independent core regions of Northern Ireland, and the East in Ireland, with respectively Belfast and Dublin, respectively as their urban agglomerates. The independent agglomerates of Madrid, Cataluna, and Pias Vasco in Spain, and Norte and Lisbon in Portugal are situated in the south

TABLE 3.6
URBAN AGGLOMERATES OUTSIDE THE EU GEOPGRAPHIC CORE

N	Code	Regions	Dist. Duss. *d*	Dist closest *Core* *d*1	Core Reg 1997	Reg Pop Dens 1997	Nr Urb Ar.	Tot. Pop. Change 90-97	Y/P (PPS) 1990	Y/P (PPS) 1997	90-97	Unemployment U (%) 1990	Unemployment U (%) 1997	Unemployment 90-97	Employment Structure Agr. (%) 90	Agr. (%) 98	Ind. (%) 90	Ind. (%) 98	Ser. (%) 90	Ser. (%) 98	Change in Employment Structure 1990-1998 Agr. (%)	Ind (%)	Ser. (%)
1	UK13	Northumberland, Tyn	1047	99	C2:1	257.8	11	3.0	82.0	85.1	3.1	10	10.4	0.4	1.0	1.3	30.0	29.5	69.0	68.9	0.3	-0.5	-0.1
2	UK11	Cleveland, Durham	997	149	C4:1	383.2	16	15.1	85.0	81.7	-3.3	9.6	8.7	-0.9	1.0	0.8	36.0	32.5	61.0	66.1	-0.2	-3.5	5.1
3	UKB	Northern Ireland	1246	381	C5:1	118.5	6	89.0	74.0	82.2	8.2	14.5	8.6	-5.9	4.0	5.1	27.0	25.9	70.0	68.0	1.1	-1.1	-2.0
4	IE01	East	1045	167	C5:1	52.1	2	157.2	68.0	102.1	34.1	15.6	10.1	-5.5	15.0	8.5	28.0	28.3	57.0	62.5	-6.5	0.3	5.5
5	FI11	Uusimaa	1344	1241	C5:1	146.6	9	41.9	120.0	134.4	14.4	14	10.8	-3.2	2.0	1.3	22.0	20.8	76.0	78.0	-0.7	-1.2	2.0
6	SE01	Stockholm	1312	593	C5:1	270.2	3	67.6	140.0	122.9	-17.1	6.7	7.7	1.0	1.0	0.0	18.0	16.1	81.0	83.1	-1.0	-1.9	2.1
7	DK	Copemhagen	698	241	C3:1	5289.0	2	148.4	107.0	120.3	13.3	9.7	5.7	-4.0	6.0	3.7	26.0	26.4	68.0	69.7	-2.3	0.4	1.7
8	DEF	Schleswig-Holstein	471	86	C2:1	175.4	18	171.1	99.0	102.1	3.1	6.2	7.6	1.4	6.0	2.8	31.0	23.6	63.0	73.6	-3.2	-7.4	10.6
9	DE6	Hamburg	385	106	C	2251.2	1	74.1	183.0	197.1	14.1	8	8.8	0.8	1.0	1.6	24.0	22.2	75.0	76.2	0.6	-1.8	1.2
10	DE31	Berlin	543	284	C	3815.6	1	-11.1	116.0	109.0	-7.0	6.9	13.4	6.5	1.0	0.7	33.0	23.0	67.0	76.3	-0.3	-10.0	9.3
11	DE5	Bremen	363	113	C	1652.4	2	-6.1	148.0	145.0	-3.0	10.4	12.4	2.0	1.0	1.5	33.0	28.2	66.0	70.3	0.5	-4.8	4.3
12	AT13	Vienna	937	398	C	3856.1	1	60.3	153.0	164.1	11.1	5.1	6.1	1.0	1.0	0.4	28.0	21.3	71.0	78.3	-0.6	-6.7	7.3
13	IT60	Lazio	1439	424	C4:1	303.6	27	59.2	115.0	112.6	-2.4	10.9	12.4	1.5	5.0	3.3	20.0	18.8	75.0	77.9	-1.7	-1.2	2.9
14	IT80	Campania	1656	217	C2:1	426.0	32	-17.4	69.0	65.2	-3.8	19.8	25.6	5.8	12.0	8.8	24.0	23.5	65.0	67.7	-3.2	-0.5	2.7
15	GR3	Attiki	2619	2443	C4:1	905.6	2	-74.3	50.0	75.1	25.1	8.8	11.6	2.8	2.0	0.9	33.0	25.9	65.0	73.2	-1.1	-7.1	8.2
16	ES21	Pias Vasco	1453	624	C4:1	283.9	12	-98.6	90.0	94.0	4.0	19	18.8	-0.2	4.0	2.6	42.0	37.4	55.0	60.0	-1.4	-4.6	5.0
17	ES8	Madrid	1804	617	C	628.2	15	-5.5	96.0	101.2	5.2	12.4	18.3	5.9	1.0	1.1	30.0	25.5	69.0	73.4	0.1	-4.5	4.4
18	ES51	Cataluna	1393	613	C4:1	189.9	35	-102.5	92.0	100.0	8.0	12.5	17.4	4.9	3.0	3.3	44.0	38.7	53.0	58.1	0.3	-5.3	5.1
19	ES63	Ceuta y Melilla			C2:2	4244.0	2	2.7	64.0	69.4	5.4	29.8	26.4	-3.4	1.0	0.4	12.0	10.2	88.0	89.4	-0.6	-1.8	1.4
20	PT11	Norte	2104	573	C3:1	167.0	26	100.5	49.0	64.3	15.3	3.1	6.9	3.8	24.0	14.4	42.0	47.8	34.0	37.9	-9.6	5.8	3.9
21	PT13	Lisbon	2311	621	C3:1	278.0	30	7.8	76.0	92.3	16.3	7.4	7.9	0.5	10.0	5.3	31.0	28.2	59.0	66.5	-4.7	-2.8	7.5
		Total of Independent Core's			21		253	682.4	98.9	105.7		11.4	12.2		4.9	3.2	29.2	26.4	66.0	70.2	-1.6	-2.9	4.2
		Total of Geographic Core Regions			51		844	5640.8	108.4	109.9		5.8	7.4		3.9	2.8	35.1	30.9	61.2	65.9	-1.1	-4.2	4.7
		Total of all Core Regions			72		1097	6323.2	207.3	215.6		17.2	19.6		8.8	6.0	64.3	57.3	127.2	136.1	-2.7	-7.1	8.9

* Cueta y Melilla is excluded as an EU core region. It consists of two towns on the North African Medittereanean coast, and will be considered to be a Spanish foreign dependency.

d 1 = distance to the closest core-region

Source: Author's own research. Data from Erostst.

of the EU geographic core. Located to the south – east are the independent agglomerates of Lazio and Campania in Italy; and Attiki in Greece.

In concluding the section on the independent agglomerates, it must be noted that these individual agglomerates are of special interest in assessing the changing composition of their manufacturing base, employment structures, and income creation as a consequence of integration. Their individual stability is largely determined by the mobility of their labour force, their manufacturing base, and their comparative advantage. Any reduction in the size of the individual industrial complexes will substantiate the theory that industry is relocating to the geographic core, thereby potentially affecting the stability of the independent core regions.

3.7 CONCLUSIONS ON REGIONAL GEOGRAPHY

The objective of the foregoing analysis was to harmonise the nomenclature of the administrative regions to facilitate identification and categorisation of them into a core, adjacent, and periphery region framework for the individual EU countries. A mathematical model was developed to define core, adjacent, and periphery regions. The model allowed for the application of the Eurostat definition of an *urban agglomerate* to administrative regions. This application facilitates the identification of core regions within a country. The identification of the core regions is significant for the further study of agglomerations. The core region, by definition, is a measure of centrality, representing a degree of localised geographic urbanisation, and concentrated demand. Since manufacturing locates where demand is highest, we expect these core regions to show the highest levels of manufacturing concentration to conform to the theory that the core is an attraction region. The analysis allows us make the following conclusions.

First, the administrative regions, in each EU member state, have been classified into economic regions that conform the CAP model. Not only does this enable an analysis of regions within each country, but also an analysis of the regions in an integrated geographic market.

Second, the classification allows identification of the geographic location of different region types. In particular, it was demonstrated that border and coastal regions are not necessarily periphery regions, but can be any type of region in the CAP cluster.

Third, by classifying the border-regions, the periphery regions that will receive direct economic impulses from the elimination of barriers to trade were identified. This is especially true for periphery regions that border on foreign core regions. The identification of these regions facilitates the study of the degree of income convergence or divergence as a result of integration.

Fourth, the classification of administrative regions has allowed for the exact identification of the EU geographic core. This geographic core consists of a continuum of core regions – agglomerates – that creates a clear north – south divide in the European Union.

Fifth, the classification has identified the EU geographic periphery regions with their independent agglomerates. The significance of identifying these independent agglomerates is that it will enable an examination of the stability of their industrial structures.

1. The Mathematics of the CAP Model

Let U represent any country with a set of urban population density elements upd_i where $i = 1 \ldots I$. This set of population density elements can be represented by:

$$U = \{upd_i | \; i = 1,...,I\} \tag{3A.1}$$

Where i is the urban population density of a given urban area, and I is the total of all urban areas in a country. It is possible to create three proper subsets of U, with the symbols C, A, and P, such that $C \subset U$, $A \subset U$, and $P \subset U$, given the condition that $C \neq A \neq P \neq U$. By using the *extension theorem* of set theory, specific values of the elements from U can be assigned to the three respective subsets: C, A, and P. Let the function $\varphi(upd_i)$ be the criterion for the subset C, such that $\varphi(upd_i) \in C$. Subset C is then characterised by the following condition:

$$\varphi(upd_i) \in C \leftrightarrow upd_i \in U \cap \varphi(upd_i) \qquad \forall i \tag{3A.2}$$

Thus each element upd_i in U that satisfies the criterion $\varphi(upd_i)$ is assigned to the subset C. For subset A, $\gamma(upd_i) \in A$, and is characterised by the following equation:

$$\gamma(upd_i) \in A \leftrightarrow upd_i \in U \cap \varphi(upd_i) \cap \gamma(upd_i)\theta_{CA} \qquad \forall i \tag{3A.3}$$

Equation (3A.3) states that every element upd_i, in U that satisfies the criteria $\gamma(upd_i)$ and not the criteria $\varphi(upd_i)$ will be assigned to the subset A. Finally, the criterion for subset P is the same as for subset A since a region that is two regions removed from the core can theoretically have the same $\gamma(upd_i)$ as an adjacent region. However, it is differentiated from an adjacent region by its geographic location and lies in the second ring of regions around the core. The distance criterion is incorporated in equation (3A.4) indicating that the distance between the core and adjacent regions, θ_{CA} is less than the distance between the core and the periphery regions, θ_{CP}. This also implies that the distance between a periphery and an adjacent region θ_{AP} is less than the distance between the core and periphery regions, such that $\theta_{CP} > \theta_{AP}$.

$$\gamma(upd_i) \in P \leftrightarrow upd_i \in U \cap \varphi(upd_i) \cap \gamma(upd_i)(\theta_{CP} > \theta_{CA} \geq \theta_{AP}) \qquad \forall i \tag{3A.4}$$

The extension theorem holds only if the following conditions are met. If $\varphi(upd_i) \rightarrow C \cup (A \cup P) = U$, $\gamma(upd_i) \rightarrow A \cup (C \cup P) = U$, and $\gamma(upd_i)(\theta_{CP} > \theta_{CA} \geq \theta_{AP}) \rightarrow P \cup (C \cup A) = U$, then:

$$\exists \quad C \cup A \cup P(\theta_{CP} > \theta_{CA} \geq \theta_{AP}) = U \qquad \forall i \tag{3A.5}$$

and

$$\exists \quad C \cap A \cap P(\theta_{CP} > \theta_{CA} \geq \theta_{AP}) = \varnothing \qquad \forall i \tag{3A.6}$$

The regions are disjoint because of the urban population density – and distance criteria assigned to each subset of regions. The regions are individual non-overlapping units bordering on each other in the order as given by equation (3A.6). The universal set of regions can be rewritten as follows:

$$U = \bigcup_{j=1}^{J} R_j \qquad \forall i \tag{3A.7}$$

Then one may write,

$$U = \bigcup_{j=1}^{J} R_j = C \cap A \cap P(\theta_{CP} > \theta_{CA} \geq \theta_{AP}) = \varnothing \qquad \forall i \tag{3A.8}$$

For any country, U, the union of its regions is a disjoint universal set. The union of the regions is a collection of a number of core, adjacent, and periphery regions that are non-overlapping as defined by the extension and distance criteria of set theory. This is expressed in the following equation;

$$U = \bigcup_{j=1}^{J} R_j = \sum_{j=1}^{C} C_j \cap \sum_{j=1}^{A} A_j \cap \sum_{j=1}^{P} P_j(\theta_{CP} > \theta_{CA} \geq \theta_{AP}) = \varnothing \tag{3A.9}$$

This equation states, that for any country U, the union of its administrative regions is equal to the sum of its economics regions; core, adjacent, and periphery. These regions form a non-overlapping collective. This model serves as a framework to study the dispersion of economic activity within the geographic confines of a country.

2. Classifying the Regions

The analysis in this section is based on the CAP model set out in equations (3A.1) - (A3.9). To begin the analysis of the economic geography of the EU with the CAP model, this section identifies and classifies the *core, adjacent,* and *periphery regions* within the individual EU Member states. Regional classification is based on a region's urban population density, which complies with the theoretical criterion of large market demand. This analysis adopts the Eurostat definition for the size of an urban agglomerate and uses it to classify the individual NUTS 2 regions of a country.

The urban agglomerate definition defines the minimum criterion for the population density value of a core region. Once the core regions have been identified, the urban population densities of the remaining regions can be deduced. Any adjoining region or first-ring region around the core that does not satisfy the primary definition must be an adjacent region. In terms of concentric-circle theory, an adjacent region would be called a first-order contiguity region.

A second-order contiguity region is a region in the second circle of regions around a core region and is called a periphery region. The geographic spatial distance from the core region to adjacent region (θ_{CA}) is less than that of the core region to the periphery region, (θ_{CP}). Therefore, although the minimum urban density value identifies the element in the subset core region, all the elements with a lower value are contained in the subset adjacent and periphery regions. The determining criterion for an element to be contained in the periphery subset is distance.

Given the criterion for the elements of the subsets of the *C*, *A*, *P* regions, the empirically specified values that have previously been defined in Section 3.2 can be substituted in each subset. For the core regions from equation (3A.2):

$$C = \{\varphi(upd_i) \in C \mid \varphi(upd_i) \geq 500\} \tag{3A.10}$$

Where *C* represents a core region with an urban agglomerate equal to or greater than 500 people per square kilometre.

Similarly, from equation (3A.3) for an adjacent region,

$$A = \{\gamma(upd_i) \in A(\theta_{CA}) \mid 20 \leq \gamma(upd_i) < 500\} \tag{3A.11}$$

This indicates that a first order contiguous region contains an urban area with a minimum population density of 20 but less than 500 people per square kilometre.

The criterion for a periphery region - a second order contiguous region - is identical to that of an adjoining region, but differentiated from it by the distance criterion. From equation (3A.4), it is defined as:

$$P = \{\gamma(upd_i) \in P(\theta_{CA} < \theta_{CP}) \mid 20 \leq \gamma(upd_i) < 500\} \tag{3A.12}$$

Although the criterion for the adjacent region is theoretically identical to that of the periphery region, the distinction between the two is determined by geographical distance from the core region. A periphery region is, per definition, two regions removed from a core region. It is distinguished from the adjacent region by definition and by the distance criterion. The regions are administrative NUTS 2 regions categorised into economic regions.

The symbols C, A, and P, represent subsets of regions with one or more urban areas of a specified population density. This classification can be redefined to take into consideration the population density, x, of one or more urban areas in a region, as well as the number of urban areas, y, in the region that satisfies the given criterion. The core region can be symbolically used as an example, which applies to all regions in the CAP model. Given:

$$C = \varphi(x, y) \qquad (3A.13)$$

Where, C indicates the type of region as defined by the subset function φ, the variable x equals the subset's minimum population density criterion, and y represents the number of urban areas in the region that meet the criterion.

For example, the region of Düsseldorf is classified as (C2:5) where $x = 2$, and $y = 5$. This means that the core region of Düsseldorf has an urban population density equal to or greater than 2,000 people per square kilometre ($x \geq 500 = \varphi(upd_i)$). It consists of five urban areas, each of which satisfies, but happens to significantly exceed, the criteria for that subset. In the regional notation, there is an inverse relation between the increasing values of x and the declining values of $\varphi(upd_i)$ exceeding the criterion for that subset. The classification of the regions proceeds in the following manner. If $x = 0$, the region is classified as an official (Eurostat) single city core region (C) or monocentric region, with no agricultural production. If $x = 1$, and $y = 0$, the core region is symbolised by ($C1$) indicating that the region consists of a number of contiguous urban areas, with no agricultural production. A core region characterised by ($C3$:2), means two urban areas with a population density of 1,000 people per square kilometre but less than 2,000. The symbolism used in the CAP model thus reflects two important characteristics of a region, namely, urban population density and the number of urban agglomerates in the region with a similar or greater population density. The same notation is used for the adjacent and periphery regions.

3. Economic Integration

Economic integration has created a new larger geographic market with multiple CAP regions. By summing over all the countries in the union equation (3A.9) becomes:

$$EU = \sum_{i=1}^{U} U_i = \sum_{i=1}^{U} \sum_{j=1}^{C} C_{ij} \cap \sum_{i=1}^{U} \sum_{j=1}^{A} A_{ij} \cap \sum_{i=1}^{U} \sum_{j=1}^{P} P_{ij} (\theta_{CP} > \theta_{CA} \geq \theta_{AP}) = \varnothing \qquad (3A.14)$$

Where, EU represents the economic union and is the sum of the individual countries U_i where $i = 1\ldots$, U, and U is the total number of countries in the union. The variable C_{ij} represents the j^{th} core region in the i^{th} country; A_{ij} is the j^{th} adjacent region in the i^{th} country, and P_{ij} the j^{th} periphery region in the i^{th} country. The condition ($\theta_{CA} < \theta_{CP}$) holds for all periphery regions in the union.

1.2 EU Geographic Core

The EU geographic core is expected to be a continuum of adjoining core regions C_{ij} that stretches through the countries of the EU, such that the geographic core is defined as:

$$GC = \int_i^j C_{ij} d(i) d(j) \tag{3A.15}$$

Where, j represents the core region and i the country in which the region is located, subject to the condition that $i \neq j$.

1.3 Calculating Average Values

Let, R_j represent the core, adjacent, and periphery regions, we can find the average values of the variables in the characteristic vector by modifying equation (3A.14) as follows:

$$\overline{E} = \frac{1}{U}\sum_{i=1}^{U} U_i = \frac{1}{C}\sum_{i=1}^{U}\sum_{j=1}^{C} C_{ij} \cap \frac{1}{A}\sum_{i=1}^{U}\sum_{j=1}^{A} A_{ij} \cap \frac{1}{P}\sum_{i=1}^{U}\sum_{j=1}^{P} P_{ij}(\theta_{CP} > \theta_{CA} \geq \theta_{AP}) = \varnothing \tag{3A.16}$$

Where, $\overline{E}$ represents the average values for the EU, U represents the total number of countries in the union, and C, A, and P the respective number of core, adjacent, and periphery regions found per country through the regional classification criteria.

TABLE 3B.1

CLASSIFICATION OF NUTS 2 REGIONS INTO CORE, ADJACENT, PERIPHERY, AND ISLAND PERIPHERY

DESCRIPTION OF AREA TYPES		
CORE		
1	C	= a single city region
2	C_1	= multiple city region with no employment in agriculture
3	C_2	= contains one or more urban area's (UA) with a population density ≥ 2 thousand / km²
4	C_3	= contains one or more urban area's with a population density ≥ 1 thousand / km²
5	C_4	= contains one or more urban area's with a population density ≥ 500 / km²
6	C_5	= a single national urban area with a population density (PD) < 500 / km²
ADJACENT		
7	A	= any adjacent region which completely surrounds a core region
8	A_1	= any region adjacent to a core with one or more UA's with a PD between 100 - 500 / km²
9	A_2	= any region adjacent to a core with one or more UA's with a PD between 50 – 99 / km²
10	A_3	= any region adjacent to a core with one or more UA's with a PD less than 50 / km²
PERIPHERY		
11	P_1	= a region bordering on an adjacent or other periphery with one or more UA's with PD ≥100 / km²
12	P_2	= a region bordering on an adjacent or other periphery with one or more UA's with PD ≥ 50 / km²
13	P_3	= a region bordering on an adjacent or other periphery with one or more UA's with PD ≥ 20 / km²
14	P_4	= a region bordering on an adjacent or other periphery with one or more UA's with PD < 20 / km²
ISLAND PERIPHERY		
15	IP_1	= a peripheral island region with one or more UA's with a PD ≥100 / km²
16	IP_2	= a peripheral island region with one or more UA's with a PD ≥ 50, / km²
17	IP_3	= a peripheral island region with one or more UA's with a PD between 20 – 49 / km²
18	IP_4	= a peripheral island region with one or more UA's with a PD < 20 / km²

Source: Author's own classification scheme.

Table 3B.1 ranks the regions according to the size and number of urban areas. For example, Brussels is a C, which indicates it is an official region with an urban area whose size is equal to that of the county. Greater Manchester is a C1, which indicates that it is a multiple urban region with no agricultural production. Düsseldorf is a C2:5 indicating that it is a core region containing five urban areas each with a population density greater than 2 thousand / km^2 .

The core region definition is contravened in the case of a C5 core region. In cases where autonomous national countries only have one major population agglomerate with a population density less than 500,000, it will be symbolised with a C5, such as is the case for Belfast, in Northern Ireland, and Dublin in the region called East. An example of an adjacent region completely surrounding the core region is the adjacent region of Brandenburg that surrounds the core region, Berlin. It is symbolised by A:1 indicating that it contains one urban area with a population density greater than 100 / km^2. The adjacent region Niederösterreich is an A:2 indicating that the region surrounds a core region, and contains one urban area with a population density greater than 50, but less than 100. Niederösterreich (AT12) is the only adjacent region to the core region of Vienna (AT13). The terms in brackets are the official NUTS 2 codes for the regions.

CHAPTER 4

TESTING THE STRUCTURAL SIGNIFICANCE OF THE CAP MODEL

4.1 Introduction

In Chapter 3, the two-region, core periphery model (Krugman, 1991b) was extended to include adjacent region types found within a national economy. The resulting three-region CAP model was then used to classify these different region types within the fifteen-member countries of the European Union.

The objective of this chapter is to test whether the CAP extension of the core periphery model to three regions, with the addition of the adjacent region, provides deeper analytical insights into the effects of trade liberalisation from the analysis of empirical data.

The first test is an examination of regional data for all of the regions in the European Union to determine whether the regional data conform to the structure and assumptions of the CAP model. The second test is to measure the statistical significance of the influence of geographic location and the structure of employment on regional per capita income within the framework of the CAP model. If European Union regional data reveals the presence of adjacent regions and the regression analysis demonstrates that these regions provide statistically significant explanatory data, then the extension of the CAP model is a valid and useful structural refinement of the core-periphery formulation.

This chapter is divided into two sections. Section 4.2 examines regional demographic and economic changes in the European Union *ex ante* and *ex post* EU 1992. In Section 4.3 a multiple regression model tests the CAP model as to whether the adjacent region provides statistically significant results.

4.2 DEMOGRAPHIC AND ECONOMIC DEVELOPMENTS IN THE EU CAP REGIONS

4.2.1 Demographic Developments

Using the regions in the EU, as classified in Chapter 2, it is possible to examine the labour issue raised by Doyle (1989), Krugman (1991b), and Venables (1994) with respect to migration. Doyle (1989) expressed concern that trade liberalisation would lead to the migration of populations from periphery to core regions and called for a new regional policy to mitigate these relocations. Krugman (1991b) argues labour is perfectly mobile within a country and will relocate from the periphery to the core in response to employment incentives. Venables (1994), on the other hand, argues that the wage differential between the core and periphery will stimulate the competition effect, thereby attracting labour to the periphery. Ludema and Wooton (1997) argue that labour is imperfectly mobile between countries. The issue to be examined is, whether populations relocate to core regions in response to trade liberalisation as theorised by Krugman (1991b).

The EU demographic data for the CAP model in Table 4.1 indicates that, on average, the average population densities in the EU CAP regions increased marginally. The core regions have collectively experienced a net increase of over five and a half million people. The adjacent regions experienced a net total increase of one and a half million people over the same period. Surprisingly the periphery regions did not experience a collective net decline in their total population. To the contrary, they experienced a net population increase of six hundred and ten thousand people. Only the island periphery regions saw a population outflow. The population density data indicates declining population levels on the radius extending away from the core supporting the theory of the CAP model.

These results are evidence of the home market and the competition effect on population movements (Krugman, 1991b). As is evident in Table 4A.1 (Chapter 4, Appendix 4A), the EU core regions attracted the largest population inflows thereby providing preliminary evidence of economic geography effects. Population relocation has occurred primarily in the regions within EU geographic core. The net population increase in the adjacent regions was approximately one quarter of the increase in the core regions. Seventy-nine percent of the total EU adjacent regions experienced population growth. The periphery regions also showed an increase in population growth. On balance, seventy percent of the EU periphery regions experienced positive population relocation.

Since labour is domestically mobile in pursuit of employment opportunities, relocation of labour to national periphery regions implies the development of self-sustaining economic activity and long-term income opportunities in these regions. This is a significant development for three reasons. One, it provides evidence of the success of the new EU regional policies in preventing the export of unemployment (Doyle, 1989). Two, it supports the theory of cumulative causation starting from very low initial levels of capital accumulation (Krugman and Venables, 1996). Three, it supports the theories of diversified agglomeration (Venables, 1994; Ludema and Wooton, 1997; Forslid and Wooton, 1999).

4.2.2 Economic Developments in the CAP Regions

The new economic geography trade theory assumes that manufacturing will locate where its markets are largest, but its markets are largest where population density is highest. The theory further assumes that per capita incomes are highest in the core regions and declines progressively along the radius extending to the periphery. The decline in income is the result of the transport intensity of manufactured products (Venables and Limao, 2002). The higher the transport intensity of a product, the closer the location of its production will lie to the regional core, and the less manufacturing production will occur in the periphery. With the removal of trade barriers, some manufacturing will relocate from the periphery to the core resulting in increased unemployment in the periphery regions.

The previous section has illustrated the inverse relationship of population densities and distance in the regional CAP model. Given this fact, it is reasonable to expect a positive relationship between the levels of per capita income and a region's CAP classification. This section addresses two questions. First, is there a significant difference between the levels of per capita income in the CAP regions, and has

TABLE 4.1

CAP-MODEL DEMOGRAPHIC AND ECONOMIC STATISTICS

Regions	Population Density (x 1,000)		Change in Total Pop. (x 1,000)	CAP-Model Average Index of Regional Per Capita Income (PPS)				Unemployment (%)					Regions' Structure of Employment: Agriculture (%)		Industry (%)		Services (%)	
CAP-Model *202*	1990	1997	90-97	1990	1995	1996	1997	1990	1995	1996	1997	1998	1990	1998	1990	1998	1990	1998
EU 15 Averages				92.3	94.9	95.1	95.3	8.6	11.0	11.0	11.0	10.7	8.7	6.3	31.5	28.6	59.7	64.8
CORE																		
Net Total 72			5830															
Average	768.1	787.0	81	106.7	110.1	109.9	110.1	7.6	9.2	9.0	9.0	8.4	4.0	2.7	33.5	29.7	62.7	67.3
Standard Deviation	1149.2	1167.0	94.9	26.2	27.2	25.5	25.3	4.6	5.3	4.7	4.3	4.3	4.1	2.3	8.7	8.4	10.5	9.3
ADJACENT																		
Net Total 79			1522															
Average	152.0	162.8	19.3	89.4	91.2	92.1	92.5	8.0	9.8	9.9	9.9	9.4	9.0	6.5	32.6	29.7	58.6	63.7
Standard Deviation	117.9	125.5	83.6	23.9	19.6	19.5	19.5	4.1	4.9	5.2	5.3	5.4	9.1	6.1	7.1	6.1	10.1	8.5
PERIPHERY																		
Net Total 39			610.0															
Average	68.4	72.6	15.6	78.9	80.9	80.7	80.5	10.4	12.0	12.3	12.3	11.9	14.8	10.9	28.0	26.7	56.1	62.2
Standard Deviation	47.1	52.2	69.2	26.5	19.2	18.8	18.7	6.1	7.1	6.9	6.6	6.7	12.7	8.7	5.2	5.1	14.5	8.0
ISLAND PERIPHERY																		
Net Total 12			-60.2															
Average	113.5	114.0	-5.02	61.6	68.7	68.8	68.6	9.3	10.8	11.2	10.9	10.9	16.5	12.4	22.8	21.2	60.4	66.4
Standard Deviation	91.3	93.6	24.8	18.5	15.1	14.1	14.7	7.8	7.6	7.7	7.6	7.8	10.8	7.7	6.1	4.5	12.4	7.4

Source: Author's own research.

convergence or divergence of income levels occurred? Second, how has the structure of employment in the CAP regions changed over time?

4.2.2.1 Income Differences in the CAP Regions

The average per capita income[51] for the CAP regions are presented in Table 4.1. The EU 15 average per capita income value is the mean value of the annual regional per capita income index. The average level of per capita income for the entire EU geographic market increased by 3.0% from 92.3% in 1990 to 95.3% in 1997. The average levels of per capita income are also reported for the individual CAP regions. As expected, the data reveals different levels of average per capita income for the CAP region types. The average level of per capita income is highest in the core regions and lowest in the island periphery regions. This supports the theory of a positive relationship between population density and per capita income. This outcome is evidence of the concentric circle theory underlying the CAP model.

To answer the question, 'Is there a significant difference between the levels of per capita income in the CAP regions?' the Tukey-Kramer Procedure[52] was used to determine whether the average per capita income levels of the CAP regions were significantly different from each other. The Tukey-Kramer Procedure is a single factor analysis of variance procedure to determine which means, in a set of c means, are significantly different from each other given unequal sample sizes. In Table 4.1, the average levels of per capita incomes have been calculated for four samples of unequal size – the core, adjacent, and periphery regions – for four different time periods. The Tukey-Kramer procedure permits a concurrent examination of comparison between all pairs of CAP average per capita income means in a given year.[53] The null hypothesis states that there is no difference among the average per capita income levels in a given year. The alternative hypothesis states that not all means are equal. The test was applied to the average per capita income data in Table 4.1 for each of the years for which values are recorded.

For the data observations on each year, the Sum of the Squares Within (*SSW*) groups was calculated. This allowed a determination of the Mean Square of the Sum Within (*MSW*) given that the number of levels in each year $c = 4$, and the total number of regions $n = 202$. The upper-tail critical value Q_U from the Studentized range distribution with $c = 4$ degrees of freedom in the numerator, and $n - c = 202 - 4 = 198$ degrees of freedom in the denominator is given to be $Q_U = 2.37$.

The results of the test are given for $c\ (c - 1)/2 = 6$ pairs of means for a group-to-group comparison for each year. The analysis shows that in all the group-to-group comparisons, the absolute difference between the average per capita income levels exceed their respective critical range. The one exception is in 1995 between the means of the periphery region and the island periphery regions. In this case, the absolute difference between the means (12.2) is marginally less than the critical range (12.37),

[51] Regional per capita income is an annual indexed variable used to rank and compare the per capita income development of the regions.
[52] Levine, D. Berenson, M. L., and Stephan, D., (1999), 'Statistics for Managers (2/ed)', *Prentice Hall, New Jersey, Chapter 10*

so that the null hypothesis cannot be rejected. This situation changes in the following years. The conclusion of the analysis is that the null hypothesis is rejected, and the alternative hypothesis that there is a significant difference between the average per capita levels of income in the CAP regions, is accepted.

4.2.2.2 Income Convergence Between the CAP Regions

To answer the question whether there is a convergence of per capita income between all the EU regions, the measures of central tendency and variation for each of the per capita income series 1990 – 1997 is calculated. These statistics are listed in Table 4.2 below. A measure for the convergence of per capita income is the distribution of the observations around the mean value of a variable. The wider the distribution around the mean, the more dispersed and dissimilar are the observations. The smaller the distributions around the mean, the more similar are the observations. The most widely used measures of distribution around the mean are the standard deviation and the variance of the observations. The smaller the standard deviation, the smaller the variance, and the more similar the numerical values of the observations will be.

TABLE 4.2
MEASURES OF CENTRAL TENDENCY AND VARIATION

CENTRAL TENDENCY	*1990*	*1995*	*1996*	*1997*
Mean	92.3	94.9	95.1	95.3
Median	95.0	93.0	92.8	93.8
Mode	95.0	96.0	104.5	102.1
Midhinge	93.5	92.5	92.6	92.1
Interquartile Range	31.0	31.0	28.5	28.2
Midrange	106.5	119.0	118.5	119.8
Skewedness	-0.04	0.93	0.85	0.88
VARIATION				
Standard Deviation	28.1	25.7	24.8	24.8
Sample Variance	786.4	658.8	616.7	615.7
Coefficient of Variation	30.4	27.1	26.1	26.0
Minimum	30.0	43.0	43.8	42.5
Maximum	183.0	195.0	192.5	197.1
Count	202	202	202	202

Source: Author's own calculations

The statistics in Table 4.2 provide some evidence for the convergence of per capita incomes between the regions. First, both the standard deviation and the variance are decreasing in each of the years under consideration. The change in the variance over the period 1990-1997 is -21.7%. Further evidence of convergence is provided by the coefficient of variation that declines by 14.5%. Second, from 1995 to 1997 the value of the interquartile range declined from 31.0% to 28.2%. The interquartile range consists of 50% of the ordered observations of the variable. Since this value range is declining over the years, the statistic suggests that the mid-range of values of 50% of the observations have declined. This means that there are more observations within that 50% range with a similar value, and that regional per

[53] The Tukey-Kramer Procedure's empirical results can be found in Chapter 4, Appendix (4B).

capita income convergence has taken place. It does not indicate, however, in which CAP regions the largest convergence has occurred.

To assess which of the CAP regions have contributed the most to the convergence of per capita incomes, the measures of central tendency and variance are calculated for each of the cluster of regions in the model. The changes in four of the summary statistics are presented in Table 4.3.

TABLE 4.3
CHANGES IN MEASURES OF CENTRAL TENDENCY 1990-1997

	CORE	*ADJACENT*	*PERIPHERY*	*ISL. PERIPHERY*
Interquartile Range	15.7	-1.7	-19.0	-10.80
Standard Deviation	-0.9	-4.5	-7.8	-127.7
Sample Variance	-47.1	-194.4	-353.3	-1.2
Coefficient of Variation	-1.6	-5.7	-10.4	-2.6

Source: Author's own calculations.

The core region shows an increase of 15.7% in the size of the interquartile range, indicating an increase in the diversity of per capita incomes. This increase is offset by the substantial decline in the value of the interquartile range of both the periphery (-19.0) and the island periphery (-10.8) regions over the period 1990–1997. The largest reduction in the sample variance over this period occurs in the periphery (-353.3) and the adjacent (-194.4) regions. This suggests that the largest convergence of per capita incomes occurred in the periphery regions, followed by the adjacent regions, with a minor contribution by the core regions. The change in the relative values of the coefficient of variation supports this conclusion.

The empirical evidence suggests that both the EU average level of per capita income and that of the individual CAP region types have increased over the period under consideration. Furthermore, it is also evident that a difference exists between the average levels of per capita income between the CAP regions. However, this difference is declining due to the convergence of per capita income between the periphery and the adjacent regions. This convergence of per capita incomes can only be the result of increased employment in the periphery regions, and provides a reason for the mitigation of out-migration from these regions.

4.2.2.3 The Structure of Employment in the CAP Regions

The structure of employment is defined as the percentage distribution of the labour force employed in agriculture, manufacturing, and services. The regional employment structure for the years 1990 and 1998 is presented in Table 4.1. In general, the average EU structure of employment changed between 1990 and 1998. During this period, there was a relocation of the labour force out of employment in the agricultural and industrial sectors and into the service sector. This pattern of relocation is consistent for all CAP region types.

It is also evident, that agricultural employment is lowest in the core regions and highest in the island periphery regions. Agricultural employment increases with distance from the core. The inverse is true for industrial employment. The highest percentage of industrial employment is found in the core regions and the lowest in the island periphery regions. The highest share of labour force employment exists in the service sector. This evidence supports the new geography trade theory that industry is concentrated in the core regions, and agriculture in the periphery regions (Krugman, 1991a, 1991b).

The policy effects of economic integration and the new regionalism are visible in the direction of change in the employment structure. The parallel effect of these policies was to restructure regional agricultural and industrial employment. Employment in agriculture declined in all CAP regions with the smallest decline occurring in the core regions and the largest in the island periphery regions. The elimination of barriers to trade resulted in a decline in industrial employment in the EU CAP regions. This decline in industrial employment, however, is smallest in the periphery regions. Similarly, the increased employment in the service industry is highest in the periphery regions, followed closely by the island periphery regions. These two developments support the observations that out-migration from the periphery regions is being mitigated by new employment opportunities primarily in the service industry.

The objective of this section was to examine whether developments in regional demographic and economic data could be analysed within the framework of the CAP model at the EU regional level. The stylised facts support the economic geography theory. The CAP model reveals the working of agglomeration and dispersion forces at the EU regional level. The home market effect has resulted in population migration primarily to the EU core regions, as theory predicts (Krugman, 1991b). The competition effect is evident in population migration to the adjacent and periphery regions.

Furthermore, per capita income is highest in the core regions and declines sequentially in the adjacent and the periphery regions. There is a significant difference in the average levels of per capita income between the CAP region types, with some income convergence between the adjacent and periphery regions because of the competition effect. The structure of employment in the EU is such that manufacturing employment is the highest in the core regions and lowest in the island periphery regions. Agricultural employment is lowest in the core regions and increases with distance through the adjacent regions to the periphery regions (von Thünen, 1842). The structure of regional employment is changing with labour moving out of the agricultural and manufacturing sectors and into the service sector.

Through the inclusion of the adjacent region, the CAP model shows that population density, per capita income, and manufacturing employment decline gradually with distance from the core region. Agricultural employment increases in regions more distant from the core, as concentric circle theory predicts. The following section specifies a regression equation to capture these effects.

4.3 A MULTIPLE REGRESSION ANALYSIS OF THE CAP MODEL

The stylised facts show that the CAP model is able to measure changes in demographic and economic variables as predicted by the new economic geography theory (Krugman, 1991b). More significantly, the CAP model shows the functional importance of the adjacent region in measuring agglomeration and dispersion forces between geographic region types. We now want to specify a multiple regression equation to test the CAP model by using all the classified EU region types. The empirical estimation of this equation, for two periods in time, should reveal both the significance of the CAP model for regional income determination, and the effects of trade liberalisation on regional economic structure.

We specify the following equation to captures the quantitative geographic, demographic, and economic variables of the CAP model.

$$Y/P_j = \phi(PD_j, UC_j, A_j, M_j, S_j) \tag{4.1}$$

where $(Y/P)_j$ represents the level of per capita income in region j ($j = 1,\ldots,R$) for all R European regions. The demographic variable PD_j measures the population density per square kilometre for region j, and UC_j measures a region's share of total EU urban areas per square kilometre. The employment structure in region j is measured by the percent of the regional labour force employed in agriculture A_j, manufacturing industry M_j, and the service industry S_j.

The urban concentration measure is constructed in the following manner. The square kilometre area of a region is given by the symbol D_j. The sum of EU15 regions defines the total geographic area of the EU in square kilometres, as represented by;

$$TD^{EU15} = \sum_{j=1}^{R} D_j$$

This expression defines the geographic area of all CAP regions, where $j = 1, \ldots, R$, and R represents the total number of all EU15 regions. A region's square kilometre share, R_j^D of the total EU geographic area is given by;

$$R_j^D = \frac{D_j}{\sum_{j=1}^{R} D_j}$$

where $\sum_{j=1}^{R} R_j^D = 1$. Let the number of urban areas i in region j be represented by UA_{ij}, where $i \geq j$. The case where $i = j$ is a monocentric or a city-region. The total number of urban areas TUA_j in region $j = 1$ is defined as:

$$TUA_j = \sum_{i-1}^{I} UA_{ij}$$

where $i = 1, \ldots, I$, and I is the total number of all urban areas in region j with a population size larger than twenty-thousand people. The total number of urban areas in the EU is then:

$$TUA^{EU15} = \sum_{j=1}^{R} \sum_{i=1}^{I} UA_{ij}$$

A region's urban area or urban density share in the EU total is then given by:

$$R_j^{UA} = \frac{\sum_{i=1}^{I} UA_{ij}}{\sum_{j=1}^{R} \sum_{i=1}^{I} UA_{ij}}$$

The regional urban concentration ratio UC_j per square kilometre is then defined as a region's EU15 urban density share divided by its EU15 geographic area share:

$$UC_j = \frac{R_j^{UA}}{R_j^D}$$

A region's urban concentration ratio will be greater than unity if its EU urban density share is larger than its EU geography share. Conversely, the ratio will be less than unity if the EU geography share exceeds its EU urban area share. The variable UC_j is a measure of urbanisation per square kilometre, and it is assumed that both the number of urban areas per region, and a region's circumference remain constant. The value of UC_j decreases as a region's distance from a core region increases because the urban density share declines as a larger share of a region's geographic area is devoted to agricultural production.

To capture the geographic effect of CAP region type, three slope dummies are included in the specification. The slope dummies are included to capture the effects of the quantitative variables on per capita income of each region type. The quantitative and dummy variables combined give the following specification:

$$Y_j = \beta_1 X_{1j} + \beta_2 X_{2j} + \beta_3 X_{3j} + \beta_4 X_{4j} + \beta_5 X_{5j} + \delta_1 D_1 + \delta_2 D_2 + \delta_3 D_3 + \mu_j \tag{4.2}$$

where X_{ij} 's are the quantitative variables for $i = 1,\ldots,k$ for j regions $j = 1,\ldots, R$. The effect variables for the three region types are represented by D_i for $i = 1,2,3$. The variable u_j is a normally distributed random error term with a zero mean, a constant variance, and is independent. A multiple regression analysis was performed on cross-sectional regional data to test equation (4.2) for the two periods 1990 and 1998. The estimation results and goodness of fit statistics for both periods are presented in Table 4.4.

TABLE 4.4
REGIONAL PER CAPITA INCOME ($(Y/P)_j$) ESTIMATIONS

		ESTIMATIONS 1990	*t-STATISTIC*	*ESTIMATIONS 1998*	*t-STATISTIC*
INDEPENDENT REGIONAL VARIABLES					
QUANTITATIVE VARIABLES					
Population density	PD_j	0.0060	2.4347	0.0038	1.8290
Urban concentration ratio	UC_j	-0.9487	-3.9831	-1.2275	-4.6286
Percentage employment in agriculture	A_j	-0.8850	-4.6473	-2.0078	-6.8986
Percentage employment in manufacturing	M_j	0.4647	2.9135	-0.1447	-0.6445
Percentage employment in services	S_j	0.9139	8.5083	0.4430	2.9813
EFFECT DUMMIES					
Core	D_1	36.2504	4.0221	97.5050	7.2707
Adjacent	D_2	32.5460	3.7115	86.2112	6.5587
Periphery	D_3	27.2122	3.1023	79.9699	6.2430
GOODNESS OF FIT STATISTICS					
Number of data observations / sample size	n	201		201	
Multiple regression coefficient	MR^2	0.6896		63561	
Regression coefficient	R^2	0.4755		0.4039	
Adjusted regression coefficient	AR^2	0.4513		0.3772	
Standard error	s^e	17.980		21.166	
Sum of the Squared Errors	SSE	62397.69		86463.93	
Durbin-Watson statistic	DW	1.9307		1.7896	
Calculated F-statistic	F	21.872		16.352	
Critical F-value	F^C	2.10		2.10	

Source: Author's own research estimation

Methodology

The two data samples have an equal number of observations. The quantitative variables are percentages except for the population density variable, which is measured in hundreds. The three employment distribution variables sum to unity since they measure employment distribution of the regional labour force in agriculture, manufacturing, and services. The effect variables are dummies: one for each of the three region types – core, adjacent, and periphery. Initial regression estimates reveal positive residual autocorrelation for both estimation periods. To eliminate the autocorrelation, the

Newbold (1988) calculation, τ = 1 – DW/2, is used to obtain an estimated value for ρ. The estimated τ values for the regression equations are respectively τ = 0.3172 in 1990, and τ = 0.3469 in 1998. The equations were re-estimated to eliminate the autocorrelation effects.

Goodness of Fit of the Estimation

The Goodness of Fit Statistics indicates the 1990 estimate to be the better of the two estimated regression equations. In the 1990 equation, 68.9% of the variation in the dependent variable is explained by the predictor variables, while the same variables only explain 63.6% of per capita variation in 1998. The *t*-values of the estimated coefficients are all significant at the $\alpha = 0.05$ level with the exception of the manufacturing employment coefficient in 1998, which becomes insignificant. The calculated *F*- value for both regression estimations exceed the critical value; for 1990 $F_{(8,193-8-1)} = 21.87 > F^C = 2.01$, and for 1998, $F_{(8,\ 193-8-1)} = 16.35 > F^C = 2.01$. Both of the estimated equations are free of residual autocorrelation. For the 1990 equation $d_U < 1.9307 < 2$, while for 1998, $d_U < 1.7896 < 2$. The variance inflation factor (VIF_j) analysis of the explanatory variables used in both equations revealed the absence of correlation between them.

Chow Test for Structure

The Chow test measures the pooled equation for structural stability. The joint null hypothesis assumes there are no significant difference in the estimated coefficients of the two regression equations. The restricted pooled estimation results are presented in Table 4.5.

TABLE 4.5
CHOW TEST RESULTS FOR THE RESTRICTED POOLED DATA

QUANTITATIVE VARIABLES		β_i	*t-Sat.*
Population density	PD_j	0.007	4.525
Urban concentration ratio	UC_j	-1.226	-6.222
Percentage employment in agriculture	A_j	-1.493	-9.292
Percentage employment in manufacturing	M_j	0.206	1.433
Percentage employment in services	S_j	0.601	5.907
EFFECT DUMMIES			
Core	D_1	71.821	7.781
Adjacent	D_2	62.817	7.002
Periphery	D_3	57.681	6.538
GOODNESS OF FIT			
Number of data observations / sample size	n	404	
Multiple regression coefficient	MR^2	0.7133	
Regression coefficient	R^2	0.5089	
Adjusted regression coefficient	AR^2	0.4977	
Standard error of estimate	SSE	181421.2	
Calculated *F*-statistic	F	51.3	
Critical *F*-value	F^C	2.10	
CHOW TEST			
Restricted pooled data	SSE_R	181421.2	
Unrestricted oiled data	SEE_U	148861.6	
Joint probability	J	9	
Degrees of freedom	df	396	
Calculated *F*-statistic	F	9.624	

Source: Author's own calculation.

For illustrative reasons, the unrestricted pooled estimations can be obtained via the following regression equation:

$$Y_j = \gamma_1 G_1 + \beta_1 X_{1j} + \gamma_2(X_1G_1) + \beta_2 X_{2j} + \gamma_3(G_1X_2) + \beta_3 X_{3j} + \gamma_4(G_1X_3) + \beta_4 X_{4j} + \gamma_5(G_1X_4) + \beta_5 X_{5j} + \gamma_6(G_1X_5) + \delta_1 D_1 + \gamma_7(G_1D_1) + \delta_2 D_2 + \gamma_8(G_1D_2) + \delta_3 D_3 + \gamma_9(G_1D_3) + \mu_j$$

where the variable G_1 is a dummy variable with a value $G_1 = 1$ for the 1990 pooled observations, and $G_1 = 0$ for the 1998 observations. We test the equivalence of the per capita income regression functions for the two periods by testing the $J = 9$ joint null hypothesis H_0: $\gamma_1 = \gamma_2 = ... = \gamma_9 = 0$ against the alternative hypothesis H_1: at least one $\gamma_i \neq 0$.

This equation was not estimated. Instead, the unrestricted sum of the squared errors SSE_U is calculated by adding the sum of the squared residuals from the 1990 and 1998 regression estimations. At the $\alpha = 0.05$ critical value the F- statistic, $F = 9.624$, exceeds the critical value $F^C = 2.10$. This measure of the differences in two variances, leads to the rejection of the null hypothesis that the variances of two estimates are the identical. Hence, the alternative hypothesis, H_1, is accepted that the estimated coefficients are significantly different from zero. This means that a significant structural change has occurred in the regional EU economy as the result of trade liberalisation.

Evaluation of the Estimated Regression Equations

The estimated equations support the concentric circle theory as captured in the CAP model. As expected, there exists a positive relation between per capita income and population density. We expect the value of this coefficient β_1 to be close to unity to reflect the one-to-one relationship between per capita income and population density in accordance with the home market theory that income will be highest in regions with the highest population densities. Adjusting the coefficient value, we obtain $\beta_1 = 0.6$, indicating an unequal proportional increase in per capita income du to a 1% increase in population density. In 1998, the level and the significance of this variable declines to half its 1990 value due to the increased strength of the dummy variable that captures the influence of the region types, which are defined on a population density basis.

There exists a negative relationship between per capita income and the urban concentration ratio. This outcome is contrary to expectations. Economic geography theory informs us that incomes are highest in regions with a large number of urban areas, such as the core and adjacent regions. The outcome, however, suggests that the higher a region's urban concentration share, the lower will be its level of per capita income. This outcome can be explained in two ways. First, since the value of a region's urban concentration share did not change between 1990 and 1998, the negative relationship reflects the large population inflows into cities in core and adjacent regions reducing the levels of per capita incomes in the urban areas in these regions. This is not an unreasonable explanation, since the per capita income variable measures regional income divided by total population -- young and old, employed and unemployed. As more families migrate to the cities, the average total level of urban income declines.

Second, the urban concentration measure does not capture urban growth. It simply measures a region's share of EU total urban areas. The total number of urban areas may remain constant, but they must have grown to accommodate growing populations. This argument would be consistent with the rising average per capita incomes in the core and adjacent regions, as revealed by the stylised facts in Table 4.1.

The economic variables reflect the relationship between the structure of employment and the level of per capita income. There is an inverse relationship between the level of per capita income and the share of the labour force employed in agriculture. The more people employed in agriculture, the lower will be regional per capita income. The sign on the estimated coefficient is as expected and supports the concentric circle theory. This result is consistent with income determination in the periphery regions. However, the coefficient value and the level of significance of the agriculture variable has increased in comparison to 1990, suggesting a stronger influence of agricultural employment on per capita income determination. This outcome contradicts the findings in the stylised facts.

The estimated coefficients for manufacturing employment and service sector employment are significant and have the expected signs for 1990. In 1998, the coefficient on the manufacturing variable shows a negative sign and is insignificant. This outcome reflects the declining average share of manufacturing employment across the EU regions as found in the stylised facts. Contrary to the evidence from the stylised facts, however, is the declining coefficient value and level of significance of service sector employment in 1998. The result from earlier analysis gave strong growth indications of this sector.

The coefficients of the estimated slope dummies for the core, adjacent, and periphery regions have the correct sign and are significant in both years. However, in 1998, these coefficients more than doubled in size, and their *t*-values strengthened. The increase in values suggests that the characteristics of these region types have become more significant after trade liberalisation. The Chow test supports the hypothesis of economic structural change between 1990 and 1998. Furthermore, these estimates provide strong initial evidence for the concentric circle theory and the inverse relationship between geographic location from the core and income determination. The estimations of the coefficient of partial determination and the predictive values of the regression equations are found in Appendix (4A) of this chapter.

In summarising, the estimated regression equations are initial evidence in support of the CAP model and the concentric circle theory. The Chow test provides evidence of regional structural change. The influence of these changes is also evident in the partial determination coefficients. However, even though the predictive values of the regression equations are reasonably accurate, they do not capture the direction of change of the economic variables as found in the stylised facts. Stronger yet, they contradict developments in the structure of regional employment by suggesting the movement of labour out of both the manufacturing and services sectors into the agricultural sector.

4.4 CONCLUSIONS

The demographic and economic stylised facts analysis provides sufficient statistical support for the theoretical developments in the literature of the new economic geography theory. The inclusion of an adjacent region in the CAP model reveals the validity of concentric circle theory in a regional geographic model. The stylised facts show the economic geography effects of trade liberalisation. Populations have relocated to predominantly core and adjacent regions. The periphery regions saw an average increase in their population levels as well. The structure of employment across the EU CAP regions changed, moving from agriculture and manufacturing into service sector employment. The outcome of trade liberalisation on per capita income development is evident in the regions types of the CAP model. Per capita income is highest in the core regions and declines gradually with distance through the adjacent to the periphery regions. The stylised facts reveal income convergence between the adjacent and periphery regions as evidence of new economic activity in the periphery regions, mitigating the wholesale export of unemployment.

The regression equations, however, only capture the positive relationship between region type and per capita income, supporting the theory that income declines, as production activity is located further away from the core regions. The estimated coefficients do not support the findings of the stylised fact with respect to the changing structure of employment. This suggests that the model should be re-estimated to include interaction variables to measure the interaction between the quantitative variables and the effect dummies in the European Union CAP region types, thereby strengthen the findings of the stylised facts.

TABLE 4A.1
REGIONAL POPULATION CHANGES 1990 - 1997

CORE		Pop. Change 90 - 97	ADJACENT		Pop. Change 90 - 97	PERIPHERY		Pop. Change 90 - 97
Brussels	C	-12	Limburg (B)	A1:3	37	Dessau	P1:1	-38
Antwerpen	C4:2	40	Vlaams-Brabant	A	43	Halle	P1:1	-140
Oost-Vlaanderen	C4:3	24	Brabant Wallon	A1:1	28	Anatoliki Makedonia, Thraki	P2:2	-8
West-Vlaanderen	C4:1	21	Luxembourge (B)	A1:1	12	Kentriki Makedonia	P1:1	51
Hainaut	C4:2	6	Namur	A1:1	17	Dytiki Makedonia	P3:4	9
Liege	C4:1	18	BRANDENBURG	A:1	-50	Thessalia	P2:2	12
Denmark	C2:1	148	Giezen	A1:4	79	Ipeiros	P2:1	32
Stuttgart	C2:1	290	MECKLENBURG-Vor.	A2:1	-166	Dytiki Ellada	P2:2	34
Karlsruhe	C2:1	182	Luneburg	A1:6	180	Asturias	P1:1	-58
Freiburg	C3:1	180	SACHSEN	A1:3	-412	Extremadura	P3:2	-25
Tubingen	C4:1	157	Magdeburg	A1:1	-20	Andalucia	P1:3	56
Oberbayern	C2:1	276	THURINGEN	A1:1	-221	Murcia	P2:1	29
Niederbayern	C4:3	106	Sterea Ellada	A2:1	83	Basse-Normandie	P1:1	31
Oberplatz	C3:1	78	Peloponnisos	A2:2	65	Franche-Comte	P1:1	20
Oberfranken	C3:2	58	Galicia	A1:2	-195	Pays de la Loire	P1:1	126
Mittelfranken	C2:1	113	Cantabria	A1:1	-8	Bretagne	P1:2	91
Unterfranken	C3:3	95	Navarra	A2:1	1	Poitou-Charentes	P2:4	38
Schwaben	C3:1	143	Rioja	A2:1	-6	Limousin	P2:1	-7
Berlin	C	-11	Aragon	A3:3	-24	Rhone-Alpes	P1:4	316
Bremen	C	-6	Castillia-Leon	A2:1	-105	Auvergne	P2:1	-7
Hamburg	C	74	Castillia-La Mancha	A3:5	8	Valle d'Aosta	P3:1	4
Darmstadt	C2:2	212	Comuniaded Valenciana	A1:2	20	Calabria	P1:3	-81
Kassel	C3:1	84	Champagne-Ardenne	A2:2	4	Friesland	P1:3	18
Braunschweig	C3:1	56	Picardie	A1:1	60	Burgenland	P3:3	5
Hannover	C2:1	116	Haute-Normandie	A1:1	50	Steiemark	P1:1	21
Weser-Ems	C3:3	232	Centre	A2:3	88	Algarve	P2:1	7
Dusseldorf	C2:5	101	Bourgogne	A2:2	16	Vali-Suomi	P3:1	-5
Koln	C2:2	226	Nord-Pas-De-Calais	A1:2	43	Ita-Suomi	P4:4	-10
Munster	C2:1	162	Lorraine	A1:2	2	Pohjois-Suomi	P4:2	11
Detmold	C3:1	192	Alsace	A1:2	95	Smaaland Med Oearna	P3:4	17
Amsberg	C2:3	131	Aquitaine	A1:1	106	Vaestsverige	P1:1	9
Koblenz	C3:1	135	Midi-Pyrenees	A1:1	95	Norra Mellansverige	P4:3	-14
Trier	C4:1	33	Languedoc-Roussillon	A1:2	166	Mellersta Norrland	P4:2	-6
Rheinhessen-Pfalz	C2:1	155	Provence-Alpes-Cote d'Azur	A1:4	240	OEVRE NORRLAND	P4:2	0
Saarland	C4:2	9	Piemonte	A1:5	-66	Lincolnshire	P1:1	28
Schleswig-Holstein	C2:1	171	Trentino-Alto Adige	A2:2	34	Cornwall, Devon	P1:2	51
Attiki	C4:1	-74	Veneto	A1:6	76	Dumfr.-Galloway, Strathclyde	P1:1	-100
Pias Vasco	C4:1	-99	Emilia-Romagna	A1:8	18	Highlands, Islands	P4:2	93
Madrid	C	-6	Toscana	A1:6	-34	Grampian	P2:1	2
Cataluna	C4:1	-103	Umbria	A2:2	31	Total Regions	=	39
Ceuta y Melilla	C2:2	3	Marche	A1:3	18	Average	=	15.6
Ile De France	C	422	Abruzzo	A1:3	8	Standard Deviation	=	69.2
Ireland	C5.1	157	Molise	A2:2	-5	Variance	=	4782.5
Liguria	C4:1	-81	Puglia	A1:4	19	Coef. Variation	=	4.4
Lombardia	C3:1	62	Basilicata	A2:2	-14	Net Total	=	610
Friuli-Venezia Giuli	C3:1	-18	Luxembourg	A1:3	43			
Lazio	C4:1	59	Groningen	A1:3	4			
Campania	C2:1	-17	Drenthe	A1:3	22			
Gelderland	C4:1	87	Overijssel	A1:3	41			
Utrecht	C	68	Flevoland	A1:1	75			
Noord-Holland	C3:5	104	Zeeland	A1:2	13			
Zuid-Holland	C2:1	132	Noord-Brabant	A1:4	123			
Limburg (NL)	C4:1	33	Niederosterreich	A:2	56			
Wien	C	60	Kamten	A1:1	15			
Norte	C3:1	101	Oberosterreich	A1:1	45			
Lisboa e vale do Tej	C3:1	8	Salzburg	A1:1	30			
Uusimaa	C5:1	42	Tirol	A1:1	31			
Stockholm	C5:1	68	Voralberg	A1:1	14			
Cleveland, Durham	C4:1	14	Centro (P)	A1:3	-12			
Northumberland, Ty	C2:1	2	Alentejo	A3:4	-26			
South Yorkshire	C4:1	9	Etela-Suomi	A3:7	26			

TABLE 4A.1
REGIONAL POPULATION CHANGES 1990 - 1997

West Yorkshire	C3:1		39
Bedfordshire, Hertfo	C4:1		41
Berks., Bucks., Oxfo	C4:1		82
Surrey, East-West Su	C4:1		99
Greater London	C		280
Avon, Gloucs., Wilts	C4:1		89
West Midlands (Cou	C1		27
Greater Manchester	C1		-16
Mereyside	C1		-24
Gwent, Mid-S-W Gl	C4:2		114
Northern-Ireland	C5:1		75
Total Regions		=	72
Average		=	81.0
Standard Deviation		=	94.9
Variance		=	8997.1
Coef. Variation		=	1.2
Net Total		=	5833

Oestra Mellansverige	A3:5		5
Sydsverige	A1:1		22
Cumbria	A2:1		0
Humberside	A1:1		28
North Yorkshire	A2:1		12
Derbyshire, Nottinghamshire	A1:2		49
Leics., Northamptonshire	A1:2		60
EAST ANGLIA	A1:3		97
Essex	A1:1		60
Hampshire, Isle of Wight	A1:2		84
Kent	A1:1		38
Dorset, Somerset	A1:2		49
Hereford-Worcs., Warwicks.	A1:2		44
Shropshire, Staffordshire	A1:2		37
Cheshire	A1:1		24
Lancashire	A1:1		33
Clwyd, Dyfed, Gwynedd, Powys	A1:1		-68
Bord.-centr.-Fife-Loth.-Tay	A1:3		33
Total Regions		=	79
Average		=	19.3
Standard Deviation		=	83.6
Variance		=	6986
Coef. Variation		=	2
Net Total		=	1522

Source: Authors own research.

TABLE A .4.2

PARTIAL DETERMINATION COEFFICIENTS

COEFFICIENTS		*1990*	*1998*
Per capita income / population density	$r^2_{Y/P,PD}$	0.0297	0.0170
Per capita income / urban concentration	$r^2_{Y/P,UC}$	0.0760	0.0999
Per capita income / agricultural employment	$r^2_{Y/P,A}$	0.1006	0.1978
Per capita income / manufacturing employment	$r^2_{Y/P,M}$	0.0421	0.0021
Per capita income / service sector employment	$r^2_{Y/P,S}$	0.2728	0.0440
Per capita income / core dummy	$r^2_{Y/P,C}$	0.0773	0.2150
Per capita income / adjacent dummy	$r^2_{Y/P,A}$	0.0666	0.1823
Per capita income / periphery dummy	$r^2_{Y/P,P}$	0.0475	0.1660

TABLE A.4.3

ACTUAL AND PREDICTED AVERAGE CAP INCOMES

	1990		1998	
	Actual	Predicted	Actual	Predicted
Core region	106.7	105.3	116.3	114.4
Adjacent region	89.4	92.6	95.1	95.6
Periphery region	78.9	78.2	80.6	81.0

TABLE 4A.1
TUKEY – KRAMER PROCEDURE
TEST FOR MULTIPLE COMPARISON OF SAMPLE MEANS

1990					
Core		Group 1 to Group 2 Comparison		Group 2 to Group 3 Comparison	
Sample Mean	106.7	Absolute Difference	17.3	Absolute Difference	10.5
Sample Size	72	Standard Error of Difference	2.88	Standard Error of Difference	3.46
Adjacent		Critical Range	6.83	Critical Range	8.20
Sample Mean	89.4	Means are different		Means are different	
Sample Size	79				
Periphery		Group 1 to Group 3 Comparison		Group 2 to Group 4 Comparison	
Sample Mean	78.9	Absolute Difference	27.80	Absolute Difference	27.80
Sample Size	39	Standard Error of Difference	3.51	Standard Error of Difference	5.48
Island Periphery		Critical Range	8.33	Critical Range	12.98
Sample Mean	61.6	Means are different		Means are different	
Sample Size	12				
MSW	625	Group 1 to Group 4 Comparison		Group 3 to Group 4 Comparison	
Q Statistic	2.37	Absolute Difference	45.10	Absolute Difference	17.30
		Standard Error of Difference	5.51	Standard Error of Difference	5.84
		Critical Range	13.06	Critical Range	13.83
		Means are different		Means are different	

1995					
	Core	Group 1 to Group 2 Comparison		Group 2 to Group 3 Comparison	
Sample Mean	110.1	Absolute Difference	18.90	Absolute Difference	10.30
Sample Size	72	Standard Error of Difference	2.58	Standard Error of Difference	3.09
	Adjacent	Critical Range	6.11	Critical Range	7.33
Sample Mean	91.2	Means are different		Means are different	
Sample Size	79				
	Periphery	Group 1 to Group 3 Comparison		Group 2 to Group 4 Comparison	
Sample Mean	80.9	Absolute Difference	29.20	Absolute Difference	22.50
Sample Size	39	Standard Error of Difference	3.14	Standard Error of Difference	4.90
Island Periphery		Critical Range	7.45	Critical Range	11.61
Sample Mean	68.7	Means are different		Means are different	
Sample Size	12				
MSW	500	Group 1 to Group 4 Comparison		Group 3 to Group 4 Comparison	
Q Statistic	2.37	Absolute Difference	41.40	Absolute Difference	12.20
		Standard Error of Difference	4.93	Standard Error of Difference	5.22
		Critical Range	11.68	Critical Range	12.37
		Means are different		Means are not different	

1996					
Core		Group 1 to Group 2 Comparison		Group 2 to Group 3 Comparison	
Sample Mean	109.9	Absolute Difference	17.8	Absolute Difference	11.4
Sample Size	72	Standard Error of Difference	2.48	Standard Error of Difference	2.97
Adjacent		Critical Range	5.87	Critical Range	7.05
Sample Mean	92.1	Means are different		Means are different	
Sample Size	79				
Periphery		Group 1 to Group 3 Comparison		Group 2 to Group 4 Comparison	
Sample Mean	80.7	Absolute Difference	29.2	Absolute Difference	23.3
Sample Size	39	Standard Error of Difference	3.02	Standard Error of Difference	4.71
Island Periphery		Critical Range	7.16	Critical Range	11.2
Sample Mean	68.8	Means are different		Means are different	
Sample Size	12				
MSW	461.8	Group 1 to Group 4 Comparison		Group 3 to Group 4 Comparison	
Q Statistic	2.37	Absolute Difference	41.1	Absolute Difference	11.9
		Standard Error of Difference	4.74	Standard Error of Difference	5.02
		Critical Range	11.2	Critical Range	11.9
		Means are different		Means are different	

TUKEY – KRAMER PROCEDURE
TEST FOR MULTIPLE COMPARISON OF SAMPLE MEANS

1997					
Core		Group 1 to Group 2 Comparison		Group 2 to Group 3 Comparison	
Sample Mean	110.1	Absolute Difference	17.6	Absolute Difference	12
Sample Size	72	Standard Error of Difference	2.47	Standard Error of Difference	2.96
Adjacent		Critical Range	5.85	Critical Range	7.02
Sample Mean	92.5	Means are different		Means are different	
Sample Size	79				
Periphery		Group 1 to Group 3 Comparison		Group 2 to Group 4 Comparison	
Sample Mean	80.5	Absolute Difference	29.6	Absolute Difference	23.9
Sample Size	39	Standard Error of Difference	3.01	Standard Error of Difference	4.69
Island Periphery		Critical Range	7.13	Critical Range	11.1
Sample Mean	68.6	Means are different		Means are different	
Sample Size	12				
MSW	458.4	Group 1 to Group 4 Comparison		Group 3 to Group 4 Comparison	
Q Statistic	2.37	Absolute Difference	41.5	Absolute Difference	11.9
		Standard Error of Difference	4.72	Standard Error of Difference	5
		Critical Range	11.2	Critical Range	11.8
		Means are different		Means are different	

Source: Analysis uses data from Table 4.1 – CAP Model Demographic and Economic Statistics. Data used is: 'CAP Model Average Index of Regional Per Capita Income (PPS)'.

CHAPTER 5

INDUSTRY LOCATION, STRUCTURE, AND CONCENTRATION THE CAP MODEL APPLIED TO SPAIN

5.1 INTRODUCTION

The objective of this chapter is to initiate an analysis into the workings of the endogenous economic mechanisms that comprise the 'black box' of the new economic geography model (Baldwin *et. al.*, 2002). This chapter examines the location and concentration of manufacturing industry in Spain in the context of the CAP model. In the new economic geography theory (Krugman, 1991b), reductions in trade barriers and transportation costs release forces of agglomeration and dispersion that result in the endogenous location of manufacturing industry. Theoretically, agglomeration forces combined with perfect interregional mobility of labour, results in industry relocation and concentration in the core regions with the deindustrialisation of the periphery. This represents a divergent outcome with a relative wage and cost differential in favour of the periphery region (Venables, 1994).

The new theoretical trade literature, however, also embraces theoreticians who argue in favour of a diversified outcome and wage convergence between regions. Diversified agglomeration is the result of general equilibrium effects (Krugman and Venables, 1990), relative wages differentials in favour of the periphery (Venables, 1994; Krugman and Venables, 1995), the need for input-output linkages under the assumption of labour immobility (Krugman and Venables, 1996), the imperfect interregional mobility of labour (Ludema and Wooton, 1997), regional comparative advantage with perfect labour mobility (Krugman and Venables, 1990; Forslid and Wooton, 1999), and the transport intensity of products (Venables and Limao, 2002). These theories are no less important as an explanation for international industrial development, than they are in explaining national regional economic development. Empirical studies have supported these theories at the national EU level, but no studies have been undertaken at the more disaggregated EU national regional level.

The empirical literature finds that industries requiring a high degree of internal returns to scale will locate in the core regions, while firms with a low product demand elasticity and high levels of unexploited economies of scale will be more dispersed (Brülhart and Torstensson, 1996). Haaland *et. al.*,(1999) have found that the localisation of expenditure in the home market and the need for input-output structures are determining criteria for industry concentration. Davis and Weinstein (1998; 1999) find that industries with high economies of scale located in the core regions are able to satisfy idiosyncratic (export) demand. Forslid *et.al.*, (1999) find that reductions in trade barriers lead industries dependent on economies of scale and input-output linkages to relocate to the core regions, while industries dependent on the forces of comparative advantage and specialisation locate in the periphery regions.

In a definitive empirical study of changes in industry location, ex ante and ex post EU 1992, Midelfart *et al.*,(2000) combines industry characteristics with country location. Like Davis and Weinstein (1999) in their study of Japanese prefectures, Midelfart *et.al.*,(2000) find that industrial structures of central countries are characterised by high returns to scale technology and a highly skilled labour force. Periphery countries are found to have industries with low returns to scale, low technology, and a less skilled labour force. Midelfart *et.al.*,(2000) also combine country characteristics with industry characteristics to find that central countries with a highly skilled labour force and high wages attract high technology, medium returns to scale, and capital-intensive industries. Periphery countries, on the other hand, with low wages attracted industries with low to medium returns to scale.

Midelfart *et.al.*, (2000) find a growing divergence in the production structure of EU countries indicating greater country specialisation. The marginal decline in concentration of the overall manufacturing sector and the changing spatial concentration patterns over time, is attributed to the increased EU manufacturing shares in the Southern European countries. Finally, Midelfart *et. al.*,(2000) found strong empirical results that location of industry across the EU is determined by the interaction of industry and country characteristics. These results underpin the theory of industry location on the basis of comparative advantage and new economic geography forces.

The aim of this chapter is to examine the movement of firms (n) and manufacturing labour (L), set in motion by the forces of EU trade liberalisation (reduction in ice-berg transportation costs, τ), to bring forth the absolute and/or relative concentration of regional manufacturing, in Spain. The analysis is conducted at the national regional geographic level in accordance with the framework of the CAP model, instead of the more conventional aggregated national core periphery (CP) model. Regional level analysis is significant since it allows for an examination of the endogenous forces (black box) of economic geography on the choice of firm and industry location at the micro-regional levels.

This chapter consists of six sections. Section 5.2 provides a brief discussion to explain the choice of Spain for this analysis. Section 5.3 chronicles the data sources for this analysis. Section 5.4 elucidates the changes in the regional number of firms and firm location. Section 5.5 provides an analysis of the relocation of manufacturing employment. Section 5.6 uses Krugman's (1990a) industry index measurement to analyse whether Spanish regional industry structures have converged or diverged.

5.2 INDUSTRY LOCATION IN SPAIN

Spain is of particular interest for an evaluation of the economic geography effects activated by EU trade liberalisation for three reasons.

The first reason concerns its classification as an EU geographic periphery[54] region by Krugman and Venables (1990), who theoretically examine domestic economic development in Spain by means of a

[54] Krugman and Venables (1990) use the EU index of per capita income as the centrality/periphery criteria.

trade liberalisation model. This model allows agglomeration and dispersion forces to interact with the larger EU geographic core. In that sense, the theoretical economic analysis of the behaviour of economic agents in Spain – the manufacturing sector – serves as a behavioural model of economic agents for southern EU geographic periphery regions that are subject to increased foreign competition, i.e. Portugal, and Greece. Krugman and Venables (1990) argue that it remains ambiguous whether the pull of the home market effect of the geographic core will outweigh the competition effect of the geographic periphery. This study seeks to eliminate that ambiguity.

The second reason is that, since trade liberalisation reduces market access costs to transportation costs, agglomeration and dispersion forces within Spain will ensure the endogenous location and concentration of manufacturing industry in those Spanish regions whose size and geographical location provides access to domestic and foreign core regions (Krugman, 1991b; Davis and Weinstein, 1999). In the west, Spanish regions border on Portugal, while in the northeast its regions border on southern France. The well-developed infrastructure along the northern Mediterranean coast from Spain to Italy provides a low cost market access route to the EU geographic core for the geographically located competitive eastern Spanish regions.

Given the southern geographic location of Spain, its resource endowments, and its relative wage and cost advantage (Krugman and Venables, 1990; Venables, 1994) versus the EU geographic core, theory and empirical evidence would argue that Spain could expect not only to attract industry with low product demand elasticities and high levels of unexploited economies of scale (Krugman, 1991b; Haaland *et. al.,* 1999; Midelfart *et. al.,* 2000), but also industries wishing to take advantage of strong *intra*-industry linkages, in regions with an abundance of low cost unskilled labour, to realise their competitive advantage position (Krugman and Venables, 1995; 1996; Forslid and Wooton, 1999; Forslid, *et. al.,* 1999; Midelfart *et. al.,* 2000).

These theoretical arguments and empirical findings suggest that EU wide economic integration would have a significant effect on the regional location of Spanish manufacturing production activity. The free interregional mobility of the Spanish labour force, combined with low domestic transportation costs, will fuel home market effects through agglomeration forces (Davis and Weinstein, 1999). Spain's geographic periphery status, with its relatively low wages, and abundance of natural resources, will attract capital investment due to its relatively higher rate of return versus the geographic core. The competition effect leads to higher levels of investment to acquire economies of scale, resulting in capital stock accumulation, higher employment levels, higher wages, and a convergent production outcome relative to the EU geographic core (Venables, 2000).

The third reason is prompted by the empirical work of Midelfart *et. al.,* (2000), who found that 'the spatial distribution of European manufacturing appears to be driven by developments in Southern Europe.' The authors find that as Southern European countries increased their share of European manufacturing, EU manufacturing became more dispersed during the 1980s and 1990s, which contributed to the increased spatial clustering of manufacturing. These outcomes suggest a strong geographic competition effect in Spain that outweighs the agglomeration effect of the geographic core. The findings also support the self-sufficiency theory of Venables and Limao (2002) based on a country's location, endowment of primary factors of production, commodity characteristics of transportation intensity, and factor endowments.

5.3 Data Sources and Data Organisation

The sources of industry data used in Chapters 5 and 6 of this study are as follows; Eurostat (1993), *The Structure and Activity of Industry; Data by Regions 1988/89, Theme 4, Energy and Industry*; Eurostat (1999), *Industry, Trade, and Services, Theme 4, SBS – Structural Business Statistics (Industry, Construction, Trade, and Services)*, and Eurostat (1999, 2000, and 2001), *Regions: Statistical Yearbook.* The study examines 23 industry branches per region at the NACE 2 digit level. The industrial sectors and their industry branches are listed in Appendix 5A, Table 5A.1, at the end of this chapter.

The following data is available for each industry branch i per region j: number of units (firms) in the industry, n; number of persons employed, L; gross wages and salaries, w; and, total of investments, K. This data allows the calculation of the following variables across regions; average number of employees per firm, L/n; average gross investment per firm, K/n; average gross investment per employee, K/L; average wage per employee, w/L; and, average wage costs per firm, w/n.

The industry structure in Spain is subdivided into the sectors Energy, Extraction and Processing, Engineering, and Other Manufacturing as found in the Eurostat (1993) publication, *The Structure and Activity of Industry; Data by Regions 1988/89, Theme 4, Energy and Industry*. The sector Energy consists of the public utility companies, and the extraction and processing of energy materials. The sector Extraction and Processing is composed of industries that extract and transform non-energy-producing materials. The sector Engineering consists of metal manufacturing industries as well as mechanical, electrical and instruments engineering. It represents the supplier firms of intermediate products and forms the source for economies of scale through backward linkages for final goods producers. Finally, the sector Other Manufacturing includes the final goods supplier industries, and creates forward linkages for the intermediate goods producers.

TABLE 5.1

CHANGES IN THE NUMBER OF FIRMS PER INDUSTRY BRANCH PER REGION 1989 - 1997

Change in the regions number of firms 1997-1989			es7 94	es11 77	es12 78	es13 79	es21 80	es22 81	es23 82	es41 85	es3 84	es42 86	es43 87	es61 91	es24 83	es51 88	es52 89	es62 92	es53 90		
	Spain		Canarias IP1:2	Galicia A1:2	Asturias P1:1	Canta. A1:1	P. Vasco C4:1	Navarra A2:1	Rioja A2:1	C-Leon A2:1	Madrid C	C- Mncha A3:5	Extrem. P3:2	Andalucia P1:3	Aragon A3:3	Catal. C4:1	Com. Val. A1:2	Murcia P2:1	Baleares IP1:2	Net new Firms	Exits
Energy						CAP-CLUSTER PIAS VASCO						CAP-CLUSTER MADRID					CAP-CLUSTER CATALUNA				
(1)	Electr.,Gas,Steam	E40	64	-35	1	-12	-29	-41	-1	-64	5	-38	-19	-62	-38	-167	1263	21	46	894	-506
(2)	Purif,distr. Water	E41	-91	-3821	-1267	-206	-424	-551	-132	-3283	-36	-797	-287	-675	-788	-978	-524	-27	-40	-13927	0
(3)	Q & M Energy Materials	CA	0	0	-37	0	-1	0	0	-24	7	2	-1	2	-9	-3	0	0	-1	-65	-76
(4)	Coke, Refinery, Nuclear	DF	0	5	-3	0	0	0	0	0	4	-1	0	2	0	2	-1	-1	0	7	-6
		Total	-27	-3851	-1306	-218	-454	-592	-133	-3371	-20	-834	-307	-733	-835	-1146	738	-7	5	-13091	901
		New firms	64	5	1						16	2		4		2	1263	21	46	1424	
Exreaction & Processing																					
(5)	Q & M Non-Energy Materials	CB	-1103	-51	-21	-43	-29	-22	-49	-170	-67	-157	-350	152	-88	-115	59	56	-642	-2640	115
(6)	Chmicls & Fibres	DG	7	1	18	-6	66	1	9	-1	283	48	13	135	26	667	277	48	5	1597	-1
(7)	Rubber & Plastics	DH	32	105	6	-14	42	6	2	-12	200	27	-20	66	4	476	71	24	0	1015	-46
(8)	Non-Metalic Minrls	DI	68	201	55	-25	33	22	25	162	217	72	-9	564	-21	525	611	65	45	2610	-55
		Total	-996	256	58	-88	112	7	-13	-21	633	-10	-366	917	-79	1553	1018	193	-592	2582	5222
		New Firms	107	307	79	#REF!	141	29	36	162	700	147	13	917	30	1668	1018	193	50	5597	
Engineering																					
(9)	Basic Metal Prdcts	DJ27	449	34	31	16	195	25	10	41	155	26	5	66	38	379	103	21	5	1599	0
(10)	Fabrctd Metal Prdcts	DJ28	143	-168	95	-77	562	-180	-103	-1027	840	-335	-295	-381	-364	1485	133	-125	-88	115	-3143
(11)	Machnry Equipmnt	DK	28	108	41	-3	304	22	-24	145	408	33	-4	348	24	1550	360	204	28	3572	-31
(12)	Office Machnry, Comptrs	DL3(	0	3	2	0	-1	1	-1	7	38	6	2	14	0	35	18	0	2	126	-2
(13)	Electrcl Machnry, Apparts	DL3	21	10	21	-7	-30	7	1	-2	90	35	3	37	125	169	193	28	21	722	-39
(14)	Medcal Precision Intrmts	DL3	26	61	11	9	88	18	-1	32	361	16	3	104	18	345	191	23	12	1317	-1
(15)	Motors & Trailers	DM3	2	18	12	-3	-17	24	13	51	78	34	4	58	77	298	71	25	8	753	-20
(16)	Other Transprt.	DM3	50	74	-7	-8	-7	4	3	-16	30	-6	0	121	-1	39	8	6	111	401	-45
		Total	719	140	206	-73	1094	-79	-102	-769	2000	-191	-282	367	-83	4300	1077	182	99	8605	8162
		New Firms	719	308	213	25	1149	101	27	276	2000	150	17	748	282	4300	1077	307	187	11886	
Manufacturing																					
(17)	Food, Bevrge & Tobacco	DA	-195	-684	-115	-190	-93	-351	-102	-2009	-164	-3012	-994	-2202	-713	-1712	-1732	-102	-226	-14596	0
(18)	Textiles	DB1	48	85	14	3	38	8	-14	-45	259	61	11	327	29	1017	679	90	59	2669	-59
(19)	Wearng Apparel	DB1	-19	139	-81	-69	-106	-82	-215	-292	742	102	11	-178	-78	2575	-1504	-27	-190	728	-2841
(20)	Leather & Leather Prdcts	DC	-3	21	-4	-2	0	4	214	-44	101	313	-8	189	90	204	3254	183	219	4731	-59
(21)	Wood Prdcts	DD	70	-184	52	-55	-54	-40	5	-3	-179	-18	31	-184	77	373	300	68	60	319	-717
(22)	Paper & Paper Prdcts	DE	165	297	114	-21	265	64	22	146	2714	57	34	541	-29	2701	635	74	126	7905	16352
(23)	Mncftrg, Jewlery, Musical	DN	-760	-1884	-520	-463	-886	-534	-231	-1455	46	-911	-527	-1413	-511	-1819	-1451	-519	-790	-14628	0
		Total	-694	-2210	-540	-797	-836	-931	-321	-3702	3519	-3408	-1442	-2920	-1135	3339	181	-233	-742	-12872	
		New Firms	283	542	180	3	303	76	241	146	3862	533	87	1057	196	6870	4868	415	464	20126	
		Sector Net Totals	-998	-5665	-1582	-1176	-84	-1595	-569	-7863	6132	-4443	-2397	-2369	-2132	8046	3014	135	-1230	-14776	30637
		EXIT	-2171	-6827	-2055	-1204	-1677	-1801	-873	-8447	-446	-5275	-2514	-5095	-2640	-4794	-5212	-801	-1977	-45856	ENTRY
		ENTRY	1173	1162	473	28	1593	206	304	584	6578	832	117	2726	508	12840	8226	936	747		EXIT
		TOTAL EXIT	-2171	-14437						-21777					-13447	-1977			-49661	-4148	-53809
		TOTAL ENTRY	1173	3766						10837					22510	747			37113	1920	39033
																					-14776

Source: Author's own calculations: Data from EUROSTAT.

5.4 REGIONAL CHANGES IN THE NUMBER OF FIRMS, (n).

In the new economic geography theory trade liberalisation brings about an endogenous relocation of firms and industries (Krugman, 1991b) to larger markets where other industries have located before them (Venables, 1994). Empirical research at the country level (Brülhart and Torstensson, 1996; Forslid et. al., 1999; Midelfart et. al., 2000) and at the regional level (Davis and Weinstein, 1999) has corroborated these theories.

The new economic geography theory of industry location can be applied to the micro-regional framework of the CAP model. In this model, trade liberalisation would be expected to increase the number of new firms and/or industries in the core agglomerates where firms in similar industries already exist (Krugman, 1991b; Venables, 1994; Krugman and Venables, 1996). The core agglomerates in Spain are the regions of Pias Vasco, Madrid, and Cataluna. Each of these core regions is accompanied by a set of adjacent and periphery regions. This allows us to define a CAP cluster as a core region with one or more adjacent and periphery regions.

This section examines three issues concerning the entry of new firms. One, which region types experienced the largest increase in new firms? Two, how are the new firms distributed over the regions in the CAP clusters? Three, how are the new firms distributed sectorally in the CAP clusters? These questions are relevant because they address the initial outcomes of trade liberalisation on firm n behaviour, relocation and industry growth (Krugman, 1991b). Furthermore, it will reveal the clustering behaviour of intermediate and final goods producers in a common region or adjoining regions, thereby affecting regional industry composition (Krugman and Venables, 1996).

The question of which region types experienced the largest increase in the location of new firms is of interest since it reveals the endogenous outcome of regional industry location through agglomeration and dispersion forces. The effect of trade cost reductions on firm relocation in the CAP clusters[55] is revealed by the data in Table 5.1. The net growth of industries in the core regions is positive for Cataluna and Madrid, and negative for the core region of Pias Vasco. However, the three core regions show an absolute increase in new firms in the four industry sectors, with the exception of the Energy sector in Pias Vasco. The positive growth of new firms in the core regions of Cataluna (n = 12,840) and Madrid (n = 6,578) is accompanied by significant increases in their total populations, and hence manufacturing employment[56], indicating strong agglomeration effects in the core agglomerates (Krugman's (1991b). In the core agglomerate of Pias Vasco the growth in the number of new firms (n = 1,593) is significantly

[55] The CAP cluster of Cataluna, in the east, experienced the largest increase in the number of firms in all four industrial sectors. The 22,510 new firms in this cluster represent 58% of all new firms in Spain. In the CAP cluster of Madrid, 10,837 new firms were established, which represents 28% of the total. In the CAP cluster of Pias Vasco, there were 3,766 new firms or 10% of the total. Finally, the Island Periphery regions experienced an increase of 5%, which translates into 1,920 new establishments. All three of the CAP clusters reveal an increase in the number of firms in their core regions, as well as in their adjacent and periphery regions.

[56] See Chapter 4, Table 4.8

less than the other two agglomerates. The core agglomerates together experienced an increase of 21,011 new firms.

Within each of the CAP clusters, all of the adjacent regions experienced a significant growth in the number of new firms across all industry sectors. The most significant increase occurred in the adjacent region of Communidad Valencia (n = 8,734) that borders on the core region of Cataluna in the east, followed by the adjacent regions (n = 1,700) surrounding the core region of Pias Vasco in the west, and (n = 1,416) in the adjacent regions of Madrid. The border region of Galicia, an ex ante EU 1992 periphery region in the west, reclassified ex post as an adjacent region, experienced a significant increase in new firm establishments in all four industry sectors. The adjacent regions combined experienced an increase of 11,850 new firms. The periphery regions experienced an increase of 4,252 new firms.

This outcome suggests agglomeration forces dominate in the core regions, with the competition effect dispersing firms to the adjacent and periphery regions. It verifies the concentric circle theory of the CAP model that industry concentration declines with distance from the core (Von Thünen, 1823). The three CAP clusters represent a diversified agglomeration production structure (Krugman and Venables, 1996) or what Krugman (1991a) has called a multi-agglomerate production structure.

The second question focuses on how the new firms are distributed over the regions in the CAP clusters? This question is significant in determining whether similar industry sectors consistently locate similar region types (Midelfart *et.al.*, 2000). If so, then there is a correlation between industry and region characteristics that fuel this distribution. The *regional* distributions of new firms within the relevant CAP clusters, over the period 1989 to 1997, are shown in Table 5.2. This analysis does not consider initial concentration (clusters) levels of firms in the regions. The data simply presents a distribution of new firms over the CAP clusters.

TABLE 5.2
THE REGIONAL DISTRIBUTION OF NEW FIRMS WITHIN THE CAP CLUSTERS

	CAP 1			CAP 2			CAP 3			IPR	
	C	A	P	C	A	P	C	A	P	Can	Bal
Energy		83.3	16.7	72.7	9.1	18.2	0.2	98.2	1.6	58.2	41.8
Extraction & Processing	23.8	62.8	13.3	36.1	15.9	48.0	57.3	36.0	6.6	68.2	31.8
Engineering	63.0	25.3	11.7	62.7	13.4	24.0	72.1	22.8	5.1	79.4	20.6
Other Manufacturing	22.5	64.1	13.4	67.9	11.9	20.1	55.6	41.0	3.4	37.9	62.1

CAP 1 = Pias Vasco; CAP 2 = Madrid; CAP 3 = Cataluna; Can = Canarias; and Bal = Baleares
Source: Author's own calculations.

In general, the regional distribution of firms within the CAP clusters is not uniform. There is no observable consistent pattern across the industry sectors of new firms being attracted to the core regions. Only the industry sector Engineering reveals a consistent pattern of new firms establishing themselves in the core regions. These industries include: basic metal products, fabricated metal products, machinery equipment, office machinery and computers, electrical machinery and apparatus, medical precision instruments, motors and trailers, and other transports. Each CAP cluster shows a different pattern. The location choice by these firms could be attributed to; a) the desire to 'cluster' with other firms in the industry and, b) the particular industry characteristics of these firms, c) a particular characteristic of the region. Most of these industries have been found to show strong economic geography effects, relying on increasing returns to scale and favouring home market locations (Davis and Weinstein, 1999).

In the CAP cluster of Pias Vasco, there is a proportionately higher distribution of firms to the adjacent regions while in the CAP cluster of Madrid there is a relatively higher distribution to the periphery[57] (n = 2,843) than the adjacent regions. The CAP cluster of Cataluna also shows a high distribution of firms to the adjacent regions, in particular the adjacent region of Commanded Valencia. More importantly, however, the data shows that firms in similar industrial sectors will locate in anyone of the three region types. This seems to suggest that region characteristics are less important than the characteristics of existing industries. The data appears to suggest no correlation between industry and region characteristics (Midelfart *et. al.,* 2000).

The distribution patterns of the new entrants may be due to initial 'high' or 'low' regional industry shares (Krugman and Venable, 1996; Midelfart *et. al.,* 2000). Initial 'high' or 'low' region industry shares have been calculated and are listed in Appendix 5A, Table 5A.2, of this chapter. It is evident from these calculations, and their changes between 1997 and 1989, that that the core region of Cataluna and its adjacent region of Communidad Valencia, in general, have the relative highest levels of similar industry shares in Spain. The data in Table 5.2 reveals that more than 90% of new firms in the CAP cluster, Cataluna, locate in the core agglomerate and its adjacent regions. The choice of region type by these firms could be motivated by the need for intra and inter-industry linkages, as argued by Paelinck and Nijkamp (1975), and proven by Midelfart *et. al.,* (2000), whose research finds the need for strong forward and backward linkage between certain industries. This outcome, once again, indicates that the home market effect, the competition effect, and cumulative causation influences firm's location decisions (Krugman, 1991b; Venables, 1994). The adjacent region, in accordance with its definition[58], appears to be serving its geographic function for the core agglomerate according to concentric circle theory, creating potentially strong intersectoral and interregional economic relationships between region types (Paelinck and Nijkamp, 1975).

The third question concerns the sectoral distribution of new firms within the CAP clusters. Do intermediate and final goods industries cluster, as Krugman and Venables (1996) have argued, in a common region to reap pecuniary agglomerate advantages through external and internal returns to scale? Insight into this question is gained from the information in Table 5.3 below. First, the data reveals a

[57] The two periphery regions are Extremadura and Andalucia. Extremadura is an inland border region with Portugal geographically located on a radius between the core regions of Madrid and Lisbon and serves as a trade conduit from Portugal to eastern Spain. Andalucia is a southern coastal periphery region. It has three urban areas whose population densities are larger than 100 but less 500 people per square kilometre. It has the largest relative number of urban areas and total population of the Spanish regions.

[58] For the definition of an adjacent region see Section 3.2.4 of this dissertation under Contiguous Region.

concentration of new firms in the Energy sector in the cluster of Cataluna. Second, both Madrid and Cataluna have an approximate equal increase in the sectors Engineering and Other Manufacturing.

TABLE 5.3

THE DISTRIBUTION OF FIRMS IN INDUSTRIAL SECTORS WITHIN THE CAP CLUSTERS

	CAP 1 PIAS VASCO	CAP 2 MADRID	CAP 3 CATALUNA	IPH CAN / BAL
Energy	0.2	0.2	5.7	5.7
Extraction and Processing	15.7	17.9	12.9	8.2
Engineering	48.4	29.4	26.5	47.2
Other Manufacturing	35.7	52.5	54.9	38.9

Source: Author's own calculations

Third, the most notable aspect of these calculations is the substantial change (48.4%) in the Engineering sector in the CAP cluster of Pias Vasco. Industry development in the CAP cluster of Pias Vasco is starting from initial 'low' industry shares. The Extraction and Processing sector showed a comparable rate of change to that of Madrid. However, the Engineering sector experienced the relative largest entry of new firms of the three CAP clusters. Combined, these two industrial sectors suggest a growth of upstream industries, thereby creating an economic climate for potential agglomeration forces in this CAP cluster (Krugman and Venable, 1996).

Fourth, and most important, the outcomes in Table 5.3 also reveal almost equal growth proportionality between the industry sectors Engineering and Other Manufacturing in the CAP cluster Pias Vasco and the island periphery regions, providing an 80% average of new firms. In the CAP clusters Madrid and Cataluna the two sectors show equal growth proportionalities between the sectors providing an 81% average of the new firms in the respective clusters. This outcome again underscores what Krugman and Venables (1996) have argued, that upstream and downstream industries with mutual interdependencies have a tendency to cluster. Mutual industry interdependence means intra and inter-industry linkages, which conforms to the definition of an industry complex (Paelinck and Nijkamp, 1975; Meyers, 1983). The data in Table 5.3, provide further evidence of dispersed agglomeration in Spain, as does the regional industry share data found in Table 5A.2

The analysis of changes industry numbers, (n), has revealed that agglomeration forces compelled the largest number of new firms to locate in the core agglomerates. The competition force dispersed the remaining firms to the adjacent and periphery regions. The reason for the distribution of firms to specific regions needs to be found in the characteristics of both the firms and the regions in which they located. There appears to be a strong location relationship between upstream and downstream industries suggesting mutual interdependencies in the form of intra and/or inter-industry linkages.

These preliminary results show the advantage of using the CAP model for regional economic geography analysis over the CP model. The CP model only allows industry relocation to either a national core or national periphery (Krugman, 1991b). This observation is made crystal clear by the empirical work of Forslid *et.al.,* (1999), evidence of which is diagrammatically presented in Figures 2.8 and 2.9, in

Chapter 2 of this dissertation. The CAP model allows firm location to a seamless contiguous 'in-between' region conform von Thünen's (1823) concentric circle theory.

5.5 MANUFACTURING EMPLOYMENT, (*L*)

The empirical analysis of the previous section revealed the significant entry of new firms (n) in the CAP clusters in response to EU trade liberalisation. The outcome of the previous section showed the largest number of new firms located in core agglomerates, there is no uniform distribution of firms over the region types in the CAP clusters, similar firms locate in all region types, and intermediate and final goods industries locate in common regions. The new economic geography theory argues that labour (L) is interregionally mobile and will migrate to regions in search of higher wages (Krugman, 1991b). The restructuring of Spanish industry, post EU 1992, resulted in the exit of firms and the entry of new firms. The exit of firms led to regional unemployment and an excess labour supply, while the entry of new firms increased the demand for labour. The data pertaining to regional changes in manufacturing employment are found in Appendix 5A, Table 5A.3.

This section examines the effects on manufacturing employment of the restructuring of Spanish industry. It seeks to answer the following questions. First, in which industrial sectors did the rationalization of production generate the largest loss of manufacturing employment? Second, in which industrial sectors and industry branches were new employment opportunities created? Third, is there a relationship between the entry of new firms into industry branches and the creation of new employment opportunities? Fourth, how have regional industry structures changed due to greater trade liberalisation?

5.5.1 Employment Relocation[59]

Labour force relocation is revealed through changes in employment positions – losses and creations. We are interested in answering the question, 'In which industrial sectors did the rationalization of production generate the largest loss of manufacturing employment?' Total employment losses can be analysed per industry sector and per CAP cluster. The data reveals a *net* outflow of labour from the Energy and Other Manufacturing sectors, while the Extraction and Processing, and Engineering sectors show a *net* increase in employment creation. An examination of the CAP clusters in Table 5.4 reveals the geographic relocation of manufacturing employment.

[59] The term '*loss*' refers to a loss of manufacturing positions in industry branches in particular regions. The term '*new*' refers to new employment opportunities in industry branches in other regions within the CAP cluster. For example, from Table 5A.3, the CAP cluster of Pias Vasco experienced a *loss* 27,113 jobs in the Energy sector, while 498 *new* jobs were created in this sector but in different regions within the cluster. In this particular cluster the new jobs were created in the adjacent region of La Rioja. In the CAP cluster of Madrid, 5,791 *new* jobs were created in the core region of Madrid, 250 in the adjacent region of Castilla La Mancha, and 302 in the periphery region of Andalucia. In the CAP cluster of Cataluna, 43 *new* manufacturing jobs were created in the Energy sector in the core region of Cataluna.

TABLE 5.4
RELOCATION OF MANUFACTURING EMPLOYMENT

	CAP 1		CAP 2		CAP 3		IPR		TOTAL	
	LOSS	NEW	LOSS	NEW	LOSS	NEW	LOSS	NEW	LOSS	NEW
Energy	-27113	498	-14557	6343	-12407	51	-1995		-56072	6892
Extraction and Proces.	-8845	6673	-10618	12746	-2035	36059	-323	1532	-21821	57010
Engineering	-34064	35005	-22380	54606	-18231	75484	-3187	4682	-77862	169777
Other Manufacturing	-42616	14895	-45422	34563	-73750	95026	-9192	8251	-170980	152735
Totals	-112638	57071	-92977	108258	-106423	206620	-14697	14465	-326735	386414

(b)

	(%)		(%)		(%)		(%)		(%)	
Energy	24.1	0.9	15.7	5.9	11.7	0.02	13.6		17.2	1.8
Extraction and Proces.	7.9	11.7	11.4	11.8	1.9	17.5	2.2.0	10.6	6.7	14.8
Engineering	30.2	61.3	24.1	50.4	17.1	36.5	21.7	32.4	23.8	43.9
Other Manufacturing	37.8	26.1	48.9	31.9	69.3	46.0	62.5	57.0	52.3	39.5
Engineering + O.Man	68.1	87.4	72.9	82.4	86.4	82.5	84.2	89.4	76.2	83.5

Source: Author's own calculations form the data in Table 5.5. CAP 1 = Pias Vasco, CAP 2 = Madrid, CAP 3 = Cataluna, and IPR = island periphery regions. Engineering + O.Man = refer to the industries that can be 'footloose'.

The largest loss of manufacturing employment occurred in the CAP cluster of Pias Vasco (CAP 1). This cluster experienced a net *loss* of manufacturing employment that relocated to the CAP clusters of Madrid (CAP 2) and Cataluna (CAP 3), both of which experienced a net *increase* in manufacturing employment. The island periphery regions (IPR) of Canarias and Baleares also experienced a slight net outflow of manufacturing labour.

The distribution of employment over the industrial sectors within the CAP clusters reveals some interesting developments. Both the Energy and Other Manufacturing sectors experienced an outflow of manufacturing employment. The loss of employment in the Energy sector is consistently higher than the share of new jobs created in this industry for all three CAP clusters. The same trend is evident in the sector Other Manufacturing where the loss of manufacturing employment exceeds the shares of the newly created employment positions. This suggests a net outflow of labour from this industrial sector in the three CAP clusters.

Since there was a net creation of new jobs between 1989 and 1997, we assume that this excess manufacturing labour has been reabsorbed through the creation of new jobs in the Extraction and Processing and Engineering sectors.[60] In both industrial sectors, industry size increased in all CAP clusters. The share of newly created jobs in this sector more than doubled in all clusters, except in the island periphery regions. It appears that the Extraction and Processing – and especially the Engineering sector – experienced an increase in manufacturing employment. The employment relocation evidence across the CAP clusters reinforces an earlier tentative conclusion of multi-agglomerate production structures in Spain in and around core regions. More significant, however, are the two industry sectors to which employment is relocating. The growth of the intermediate supplier industries, Extraction and Processing and Engineering, means a growth in their concentration and levels of production (as suggested in the empirical research of Midelfart *et. al.*, 2000) and the enhanced development of internal and external

[60] This assumption is based on the theory of imperfect international labour mobility (Ludema and Wooton, 1997)

economies of scale (Krugman and Venables, 1996). This leads to the question, "In which region-types are employment opportunities in these industries increasing?"

5.5.2 CAP Cluster Redistribution of Employment

The distribution of the newly created employment positions within each CAP cluster is presented in Table 5.5 below.

TABLE 5.5
REGIONAL DISTRIBUTION OF NEW EMPLOYMENT POSITIONS

	CAP 1			CAP 2			CAP 3			IPR	
	C	A	P	C	A	P	C	A	P	Can	Bal.
Energy		100.0		91.3	3.9	4.8	84.3	15.7			
Extraction and Processing		100.0		25.9	33.8	40.3	51.1	42.2	6.7	56.6	43.4
Engineering	29.9	59.4	10.7	50.3	20.2	29.5	64.6	30.6	4.8	56.2	43.8
Other Manufacturing	1.5	82.6	15.9	61.3	27.6	11.1	43.9	50.7	5.3	48.2	51.8

Source: Author's own calculations. CAP 1 = Pias Vasco, CAP 2 = Madrid, CAP 3 = Cataluna, and IPR = island periphery regions.

In the CAP cluster Pias Vasco relocation of employment in the Extraction and Processing industry occurred across all three region types, but primarily to the four adjacent regions with the largest increase occurring in Galicia. The Engineering sector also exhibited a dispersion of new employment over all three-region types, with the highest share in the adjacent regions. Although the sector Other Manufacturing experienced a net decline in new job creation, the employment opportunities that were created are concentrated in the adjacent regions with some relocation to the periphery region of Asturias.

In the periphery region, the Engineering sector benefited from the creation of 3,739 new jobs – primarily in the industry branches fabricated metal products, and machinery equipment. In the Other Manufacturing sector, the same periphery region enjoyed the creation of 2,368 new jobs – primarily in food beverage and tobacco, and the paper and paper products industries. For the periphery region of Asturias the developments in these two industry branches represents the role of the competition effect (Krugman, 1991b), possible creation of new forward and backward linkages (Venables, 1994), and capital accumulation starting from 'low' initial levels to achieve economies of scale in production (Krugman and Venables, 1996).

In the CAP cluster Madrid, only 25.9% of new employment opportunities in the Extraction and Processing sector were located in the core region of Madrid. The remaining 74.1% was distributed almost equally over the adjacent and periphery regions, with almost the entire 40.3% being located in the periphery region of Andalucia, in the industry branch non-metallic. In the Engineering sector, half (50%) of new employment opportunities occurred in the core region of Madrid, the home market (Davis and Weinstein, 1999), while 20.2% located to the two adjacent regions. It is significant that 29.5% of new employment opportunities in Engineering were located in the periphery regions, reflecting the strong competition effect. Finally, the core and the adjacent regions of Madrid were the primary beneficiaries of new employment opportunities in the Other Manufacturing sector.

In the CAP cluster of Cataluna, the relocation of employment and the creation of new jobs occurred predominantly in the core and its adjacent regions. The 84.3% increase in the Energy sector reflects the creation of new jobs in the coke refinery and nuclear energy branch in the core region of Cataluna. In the Extraction and Processing sector, new employment opportunities were created almost equally between the core region Cataluna (51.1%) and the adjacent region of Communidad Valencia (42.2%). The periphery region of Murcia experienced an increase of 6.7%.

In the Engineering sector, the core region of Cataluna enjoyed a substantial relocation of employment and entry of firms in the intermediate goods producing industries in which the region enjoyed historical high 'initial' industry shares (Krugman and Venables, 1996). This is clear evidence of the clustering of intermediate goods producing industries and the cumulative causation process of agglomeration (Venables, 1994). Cataluna's two adjacent regions also experienced a combined increase of 30.6% new jobs in the Engineering sector, with the largest increase of 15,814 new jobs occurred in the adjacent region of Commanded Valencia, and the remaining 7,200 going to Aragon. This dispersion of Engineering employment to the two adjacent regions around the core region of Cataluna, suggests the possible strong need for *intra*-industry linkages (Krugman and Venables, 1995). It is also clear evidence of the working of the competition effect (Krugman, 1991b) in the CAP cluster of Cataluna.

In the Other Manufacturing sector, the increase in new employment creation is relatively more intense in the adjacent regions than in the core. In the core region of Cataluna 41,733 new employment positions were created as opposed to the 48,217 in the adjacent regions. Of the approximate 46,000 new jobs created in Commanded Valencia, 34,900 occurred in the industry branch leather and leather products, giving the region a high share in that industry. The periphery region of Murcia also experienced a substantial increase of employment in the industry branches: -- leather and leather goods (1,897), food beverage and tobacco (1,774), and paper and paper products (1,039).

Finally, there was an equal-proportionate increase in the shares of manufacturing employment in the Extraction and Processing, and Engineering sectors in the island periphery regions of Canarias and Baleares. The increased employment in the sector Other Manufacturing in these regions was primarily due to the relocation of labour to the food beverage and tobacco industry in Canarias, and to the leather and leather products industry in Baleares.

The analysis of employment redistribution allows us to answer the question, "In which region-types are employment opportunities in the Extraction and Processing, and Engineering sectors increasing?' In the CAP cluster of Pias Vasco these industries have located primarily in the adjacent regions. In the CAP cluster of Madrid, these industries seem to have concentrated in the core region of Madrid with dispersion to the adjacent and periphery regions. In the CAP cluster of Cataluna, these industries have located primarily in the core region with strong dispersion to the adjacent regions.

As previously observed in the industry analysis, new firms (n) in the supplier and final goods industries appear to cluster in similar regions. The growth of employment (L) in the Extraction and

Processing, and Engineering sectors in the adjacent region of Pias Vasco is accompanied by a strong growth in employment in the Other Manufacturing sector. A similar trend is evidenced in the CAP clusters of Madrid and Cataluna, as well as the island periphery regions. As mentioned in the previous section, new upstream and downstream industries appear to cluster in all region types, although not equally. Manufacturing labour migrates to where new firms are locating thereby contributing to the recomposition of regional industry employment structures (Krugman and Venables, 1996).

5.5.3 Regional Industry Shares, Employment, and Economic Districts

This section answers the question: 'Is there a relationship between the entry of new firms into industry branches and the creation of new employment opportunities?' There are regions that lost industry share, but experienced an increase in employment. The relation between industry share, labour demand, and new employment is illustrated in Table 5.6 that shows the industry branches and regions that have enjoyed an increase in manufacturing employment.

All regional industry that experienced increased shares are identified by the symbol *L* (low), *H* (high), and *C* (relatively high shares), respectively. The establishment of new firms in a region is represented by the symbol *N*. Regional industries that experienced a reduction in shares but an increased demand for labour have no symbols. For example, the adjacent region of La Rioja experienced an increased demand for labour in the industry branches electricity gas and steam, and in the purification and distribution of water, even though the number of firms in these industry branches declined. Regional manufacturing employment is also present in those industry branches that do not have an employment figure. Employment declined in these regional industry branches.

The industry share and employment data in Table 5.6 provides tangible evidence of increased industry concentration through clustering, and cumulative causation (Venables, 1994; Krugman and Venables, 1996). The Extraction and Processing sector and the Engineering sector, show increased concentration in regions with initial 'low' and 'high' shares in industry sectors. The strongest effects are evidenced in the CAP cluster of Cataluna, in the core and its two adjacent regions. Industrial clustering occurred in industries with initial high shares (*H*), and in industries with extremely high shares (*C*). The same clustering force is evident in the CAP clusters of Madrid, not only in the core agglomerate, but also in the periphery region of Andalucia.

The effect of trade liberalisation on a border periphery region is underscored in by the strong cumulative causation outcome in the *ex ante* border periphery region of Galicia in the CAP cluster of Pias Vasco. This CAP cluster also has the largest number of industries starting from 'low' initial levels in both industrial sectors. There is significant employment creation in the regions of this CAP cluster where industries experienced a decline in their numbers, such as in the core region of Pias Vasco and the adjacent region of Galicia. This outcome suggests merger and consolidation activities of firms in the Engineering sector desiring to achieve economies of scale in production.

TABLE 5.6
EMPLOYMENT CHANGE AND REGIONAL INDUSTRY SHARE

Change in the regions number of manufacturing employees		es7 94	es11 77	es12 78	es13 79	es21 80	es22 81	es23 82	es41 85	es3 84	es42 86	es43 87	es61 91	es24 83	es51 88	es52 89	es62 92	es53 90
		Canarias	Galicia	Asturias	Canta.	P. Vasco	Navarra	Rioja	C-Leon	Madrid	C- Mncha	Extrem.	Andalucia	Aragon	Catal.	Com. Val.	Murcia	Baleares
Spain		IP1:2	A1:2	P1:1	A1:1	C4:1	A2:1	A2:1	A2:1	C	A3:5	P3:2	P1:3	A3:3	C4:1	A1:2	P2:1	IP1:2
Energy																		
(1) Electr.,Gas,Steam	E40							119		1300								
(2) Purif.distr. Water	E41							379		L 2178								
(3) Q & M Energy Materials	CA									N 338								
(4) Coke, Refinery, Nuclear	DF									N 1975	250		L 302		H 43	8		
	Net							498		5791	250		302		43	8		
Exreaction & Processing																		
(5) Q & M Non-Energy Materials	CB				237						H 39	371	L 241	H 57		L 438		
(6) Chmicls & Fibres	DG	66					611	80				L 102		145	C 7797	H 2631	92	98
(7) Rubber & Plastics	DH	L 90	L 1463	213				84	83	H 696	H 374	7	H 269	646	C 6215	459	769	
(8) Non-Metalic Minrls	DI	L 711	2994				507	484	2459	H 2607	1347	392	H 3759		H 4428	H 10844	1538	567
	Net	867	4457	213	237		1118	648	2542	3303	1760	872	4269	848	18440	14372	2399	665
Engineering																		
(9) Basic Metal Prdcts	DJ27	56	857		224		684	L 365	679	H 1340	L 472	106	4162	H 454	C 5881	3429		
(10) Fabrctd Metal Prdcts	DJ28	L 1563	3212	1460				342		H 3804	1862	475	2189		C 11283	H 1746	761	253
(11) Machnry Equipmnt	DK	L 494	2266	L 1334	997	4983	3394	613	H 2267	H 1476	1694		4478	1300	C 17248	5379	H 2480	L 638
(12) Office Machnry, Comptrs	DL30		H 329	N 4		2035	N 1253			14554	H 1590	N 13	H 1056	1342	11429	H 820		
(13) Electrcl Machnry, Apparts	DL31	L 298	1018	L 253					1691					H 706		H 2762	L 259	L 59
(14) Medcal Precision Intrmts	DL33	L 97	310	150	64	1824	L 170		327	H 5420	L 114	76	H 1651	449	C 2942	H 1678	108	64
(15) Motors & Trailers	DM34	1	1361	L 538		1614	2720	L 421					H 1891	H 3023			L 5	N 479
(16) Other Transprt.	DM35	H 123					L 74	L 136		L 896	323							H 557
	Net	2632	9353	3739	1285	10456	8295	1877	4964	27490	6055	670	15427	7274	48783	15814	3613	317
Other Manufacturing																		
(17) Food, Bevrge & Tobacco	DA	L 2952	H 1028	L 1149				L 765	705	H 54		459			H 12273	H 493	L 1774	
(18) Textiles	DB17	L 235	H 775	L 500	L 51		71			H 1158	H 554	95				H 4743	L 366	L 485
(19) Wearng Apparel	DB18	47	H 4424								H 2100				C 8621			
(20) Leather & Leather Prdcts	DC			59		34	586	L 3039		59	4087		1106	2471		C 34900	H 1897	H 3005
(21) Wood Prdcts	DD																	
(22) Paper & Paper Prdcts	DE	743	H 1566	660		188			715	H 17658	1371	358	1818	147	C 18934	5463	1039	L 784
(23) Mncftrg, Jewlery, Musical	DN									H 2266					C 1905			
	Net	3977	7793	2368	51	222	657	3804	1420	21195	8112	912	2924	2618	41733	15599	5076	4274
NEW JOBS		7476	21603	6320	1573	10678	10070	6827	8926	57779	16177	2454	22922	10740	108999	75793	11088	6989

L = low initial levels *H* = high initial levels *N* = new establishment *C* = comparative advantage

Source: Authors own research. Data from Eurostat..

Pias Vasco	
LOSS	
NEW	57071

Madrid	
LOSS	
NEW	108258

Cataluna	
LOSS	
NEW	206620

Island	
LOSS	
NEW	14465

Krugman and Venables (1996) have argued that upstream and downstream industries will cluster in common locations to achieve external and internal economies of scale. Final goods producers will locate in the region that has a large base of intermediate goods producers, and vice versa. 'A [region] with a strong initial position in some industry [sector] may find itself with an advantage that cumulates over time.' The initial evidence in support of this theory was found in the sectoral distribution of new firms within the CAP clusters. The current data illustrates these dynamics in five Spanish regions where intermediate and final goods producers have found a common location. The border region of Galicia shows strong growth of both the Engineering and the Other Manufacturing sectors. In the CAP cluster of Madrid these dynamics are apparent in the core agglomerate as well as the adjacent region of Castilla La Mancha. The same is true for the core agglomerate of Cataluna and its adjacent region of Communidad Valencia.

The clustering of firms in similar industries, in the core agglomerates and their adjacent regions, suggest that industrial structures transgress the boundaries of administrative regions thereby creating economic regions with strong intra and inter-industry dependencies, as regional economists have argued (Paelinck and Nijkamp, 1975). These authors have noted that an adjacent region is an administrative region with intersectoral and interregional input-output linkages to the core region. These observations are supported by Lösch (1954) who writes that input-output structures are not by definition necessarily confined to one administrative region, but because of economic linkages, can extend beyond the borders of an administrative region to an adjacent region. Krugman (1991a) supports the regional economists' analysis. Economic structures may not simply be confined to an administrative region. Intersectoral and interregional linkages determine the size of economic input-output structures, and thus the extent of economies of scale. Krugman (1991a) states, 'There is no reason to suppose that political boundaries define the relevant unit over which...external economies apply.' The evidence seems to suggest that core and adjacent regions are creating economic districts within the respective CAP clusters. Adjacent regions seem to be development regions allowing the seamless expansion of industrial structures.

The answer to the question, of there being a relationship between the entry of new firms into industry branches and the creation of new employment opportunities, appears to be positive. The empirical evidence leads to the conclusion that trade liberalisation has stimulated the employment growth within the economic districts of the CAP clusters. This is particularly evident in the adjacent regions of the core agglomerates Madrid and Cataluna. A similar conclusion can be drawn for the CAP cluster Pias Vasco where capital accumulation is in its developments phase. In the CAP clusters[61].even industries in regions that experienced no industry growth exhibited increased demand for manufacturing labour

[61] See Table 5.8 for examples of the increases in manufacturing employment (L) in regional industries experiencing no new firm locations such as industries in the Engineering sector in Pias Vasco, or the Energy and Extraction and Processing sector in the adjacent region La Rioja.

indicating the spatial strength of the competition effect in generating new product and employment demand in existing industries

The above conclusion is further supported by the characteristics of many of the industries involved in the growth process in Spain. Davis and Weinstein (1999) find strong economic geography effects of firms in the Engineering sector in the core agglomerates. Forslid *et. al.*, (1999) have found that industries in the Extraction and Processing, as well as in the Engineering sector are dependent on intermediate inputs and require high economies of scale.[62] Further empirical evidence for this conclusion is found in Midelfart *et.al.*, (2000) where the coefficients on interaction variables show that high tech industries locate in or near the core agglomerate because of their need for strong forward and backward linkages.[63] Similar conclusions are drawn by Henriksen *et.al.*, (2001) in a cross-country study of Germany, France, Italy and the UK for specific industry branches in the Engineering sector. These issues need to be verified in a subsequent section of this thesis.

The preliminary outcome of employment relocation analysis is that manufacturing labour migrated not only to regions where new firms were being established, but also to those regions where existing industries experienced high product demand. Economic geography effects seem to be encouraged by low internal domestic trade costs and a mobile interregional and intersectoral labour force that reinforced the home market and competition effects (Davis and Weinstein, 1999). Trade liberalisation resulted in an apparent recomposition of industrial structures in the agglomerates of the CAP clusters (Krugman and Venables, 1996).

The tentative results of industry (n) and manufacturing labour (L) analysis support theoretical 'black box' dynamics of the endogenous location of industry. However, the analysis *also* accentuates the analytical value and significance of the framework of the CAP model[64] in a number of ways; a) it clearly defines the geographic boundary and the size of core agglomerates; b) it illustrates the working of the concentric circle theory that provides an uninterrupted geographic continuum of contiguous regions around the core; c) it facilitates the examination of the geographic location aspects of industry concentration and/or dispersion; d) it allows for the identification of regions with initial 'high' and 'low' shares of industry concentration; and e) it identifies the CAP clusters as measures of centrality revealing multi-agglomerate production outcomes.

The analysis has revealed a relocation of firms and manufacturing employment within the CAP clusters, primarily in the core and adjacent regions. It is evident that Spain is characterised by a multi-agglomerate production structure. It is also apparent that there has been a change in the composition of

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[62] Forslid *et. al.*, (1999). See Chapter 2, Appendix 2B, Table 2B.1.
[63] They also find that Spanish industry has a need for relatively higher returns to scale and higher technology levels that the southern EU countries of Portugal and Greece.
[64] The framework of the CAP model differs from the Venables and Limao (2002) model in that the authors assumed disconnected zones of industry location, and the immobility of labour. The essence of their theory is applicable to the CAP model, such as region and commodity characteristics.

industry structures within the CAP clusters. We now turn to the fourth question, 'How have regional industry structures changed due to greater trade liberalisation?' We examine the composition of regional production structures to assess whether there has been a convergence or divergence in industry structures within and between CAP agglomerates and adjacent regions.

5.6 Regional Industry Structures

The theoretical and empirical literature has relegated Spain to the EU geographic periphery according to the relative per capita income criteria (Krugman and Venables, 1990). Spain is a geographic area, in the southern the EU, which is composed of eighteen diverse regions, possessing a common culture, and language. Labour is mobile between industry sectors and regions. Spain has three continental core or agglomerate regions, which are of interest, since they represent independent agglomerates and therefore, a polycentric or multi-agglomerate production structure. The CAP model permits an economic geographic structure to be imposed on the regions. This facilitates the examination of the interregional structural economic relationships, and the evolution of these interdependencies, through the forces of agglomeration and dispersion unleashed by trade liberalisation.

This study posits, that historical economic development has determined the location of manufacturing activities in Spain, before it entered the EU Customs Union in 1986. This assumption is supported by the initial empirical analysis of regional industry shares.[65] Manufacturing activities are dispersed, albeit unequally, throughout the regions of Spain. The cost of domestic interregional market access, to manufacturing, is the transportation cost of traversing geographic distance, given an underdeveloped infrastructure. However, barriers to trade, for industries exporting to foreign markets, compound this cost. EU 1992 reduced trade barriers and provided reconstruction funds to improve the domestic infrastructure (EC Structural Funds (1996). In tandem, these two economic policy measures substantially reduced manufacturing trade costs, and significantly modified the competitive playing field.

In light of these developments, this section examines the effects of trade liberalisation on the composition of industry structures in the Spanish regions before, and after EU 1992. Towards this end, Krugman's (1991a) 'similarity / diversity index' is employed to assess these effects. The analysis is particularly valuable, since the industry index for 1989 and 1997, will facilitate an appraisal of the extent to which regional industry structures in the CAP clusters have converged or diverged over time.

5.6. 1 Analysis of Regional Industry Structure: Similarity / Diversity

The industry structure of a region is determined by the type and number of industry branches within a region. Krugman's (1991a) regional industry index is used to compare the increased similarity or

[65] See Table 5A.2

diversity of industry structures between regions. The industry index is constructed using regional industry employment data.

The Krugman industry index is calculated with the following statistic;

$$I = \sum_{j}^{i} \left| s_{ij} - s_{ij}^{*} \right| \qquad (5.1)$$

where, s_{ij} is the share of industry i in total manufacturing employment in region j ($i \neq j$), and s_{ij}^{*} is the regional share of manufacturing employment in the region with which the comparison is made. The industry index can take on a value from zero to two such that $0 \leq I_j \leq 0$. In those instances in which the industry structure in two regions is the same, i.e. the share of employment in the respective industries is identical, the index value will be zero. Similarly, if the industry structures in the two regions are completely dissimilar, if the index value will be 2. Based on this method, the index quantifies the difference or similarity in regional industry structure, and hence regional specialisation (See Appendix 5B of this chapter for the construction method of this index).

The industry index is calculated for the Spanish regions in 1989, and again after economic integration in 1997. By comparing these values, the similarities or the differences between industry structures are rendered apparent. Furthermore, this comparison will highlight similarities and differences between the core and adjacent regions, and non-adjacent regions *ex ante* and *ex post* economic integration. A pronounced similarity in industry structures, between non-adjacent regions, suggests a polycentric production structure, i.e. regions geographically removed from each other with similar industry structures. The significance of a polycentric production structure is, that it implies that 'increased integration [has not been] sufficiently [strong] to destabilise the existing geography of production'[66], and that industry is not concentrated in one geographic location, but instead, is dispersed.

5.6.1.1 Industry Index for Spain

The results of the analysis of the regional industry index for the two periods 1989 and 1997 are found in Table 5.7. The regions are listed in the left-hand column of the table. The reference regions are listed in the top row of the table. To make a comparison of regional values for 1989, one reads from left to right. The 1989 values are listed in the upper right hand portion of the matrix. These values indicate the similarity or difference in the regional industry structures in Spain during the period of the EU customs union before economic integration in 1992. In contrast, the 1997 values are listed in the bottom left-hand portion of the matrix. These are the post-economic integration values. In this case, a comparison of values between a particular region and its reference region is made by reading from the lower right-

[66] Krugman and Venables, (1996), p.966. Author's insertion of brackets.

TABLE 5.7
INDEX OF SIMILARITY / DIVERGENCE:
SPANISH REGIONAL INDUSTRIAL STRUCTURES, 1989 AND 1997

1989 →

				es11	es12	es13	es21	es22	es23	es24	es3	es41	es42	es43	es51	es52	es53	es61	es62	es7				
				77*	78*	79*	80*	81*	82*	83*	84*	85*	86*	87*	88*	89*	90*	91*	92*	94*				
				Gal	Aust	Cant	P.Vas	Nav	Rioja	Aragn	Madrid	C.Leon	C.Man	Extrem	Catal.	C.Val	Balrs	Andal.	Murc	Can.				
				A1:2	P1:1	A1:1	C4:1	A2:1	A2:1	A3:3	C	A2:1	A3:5	P3:2	C4:1	A1:2	IP1:2	P1:3	P2:1	IP1:2				
			i / j	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17				
es11	77 Galicia	A1:2	1	0	1.03	0.66	1.01	0.63	0.56	0.62	0.72	0.51	0.48	0.59	0.78	0.58	0.58	0.44	0.49	0.57	IP1:2	Canarias	94	es7
es12	78 Asturias	P1:1	2	0.29	0	1.00	1.09	1.11	1.23	1.05	1.16	0.96	1.18	1.15	1.20	1.21	1.01	1.08	1.03	1.17	P2:1	Murcia	92	es62
es13	79 Cantabria	A1:1	3	0.50	0.54	0	0.55	0.41	0.65	0.62	0.60	0.51	0.65	0.78	0.58	0.82	0.79	0.63	0.61	0.83	P1:3	Andalucia	91	es61
es21	80 P.Vasco	C4:1	4	0.55	0.63	0.50	0	0.66	0.94	0.67	0.67	1.00	1.08	1.18	0.72	0.99	1.08	1.00	0.92	1.17	IP1:2	Baleares	90	es53
es22	81 Navarra	A2:1	5	0.70	0.70	0.88	0.59	0	0.59	0.42	0.50	0.49	0.71	0.78	0.54	0.78	0.80	0.71	0.64	0.84	A1:2	C. Val	89	es52
es23	82 Rioja	A2:1	6	0.50	0.46	0.69	0.88	0.91	0	0.66	0.74	0.63	0.32	0.48	0.65	0.31	0.55	0.54	0.51	0.73	C4:1	Cataluna	88	es51
es24	83 Aragon	A3:3	7	0.54	0.52	0.62	0.63	0.74	0.49	0	0.40	0.51	0.70	0.78	0.45	0.65	0.84	0.66	0.76	0.99	P3:2	Extrem.	87	es43
es3	84 Madrid	C	8	0.56	0.47	0.70	0.71	0.68	0.64	0.63	0	0.64	0.79	0.92	0.29	0.73	0.97	0.75	0.80	0.96	A3:5	C.Mancha	86	es42
es41	85 C.Leon	A2:1	9	0.72	0.64	0.84	0.74	0.40	0.94	0.84	0.78	0	0.63	0.74	0.64	0.75	0.83	0.59	0.69	0.81	A2:1	C.Leon	85	es41
es42	86 C.Mancha	A3:5	10	0.67	0.67	0.91	0.68	0.48	0.90	0.73	0.57	0.56	0	0.45	0.79	0.45	0.52	0.45	0.49	0.70	C	Madrid	84	es3
es43	87 Extrem.	P3:2	11	0.46	0.48	0.45	0.48	0.66	0.69	0.60	0.49	0.75	0.71	0	0.95	0.65	0.52	0.38	0.50	0.43	A3:3	Aragon	83	es24
es51	88 Cataluna	C4:1	12	0.72	0.73	0.86	0.80	0.58	0.90	0.79	0.53	0.70	0.38	0.67	0	0.61	1.02	0.78	0.85	1.06	A2:1	Rioja	82	es23
es52	89 C. Val.	A1:2	13	0.93	0.90	1.11	0.94	0.70	1.16	1.07	0.90	0.73	0.71	0.85	0.64	0	0.58	0.63	0.57	0.79	A2:1	Navarra	81	es22
es53	90 Baleares	IP1:2	14	0.66	0.62	0.87	0.87	0.61	0.79	0.72	0.56	0.69	0.72	0.56	0.53	0.62	0	0.68	0.49	0.66	C4:1	P.Vasco	80	es21
es61	91 Andalucia	P1:3	15	0.85	0.78	0.93	0.98	0.94	0.93	0.90	0.78	0.93	0.92	0.86	0.76	0.86	0.68	0	0.36	0.48	A1:1	Cantabria	79	es13
es62	92 Murcia	P2:1	16	0.60	0.38	0.63	0.70	0.69	0.51	0.48	0.49	0.72	0.63	0.65	0.65	0.92	0.63	0.78	0	0.53	P1:1	Asturias	78	es12
es7	94 Canarias	IP1:2	17	0.46	0.45	0.63	0.51	0.32	0.75	0.56	0.52	0.41	0.43	0.47	0.48	0.70	0.50	0.73	0.49	0	A1:2	Galicia	77	es11
				IP1:2	P2:1	P1:3	IP1:2	A1:2	C4:1	P3:2	A3:5	A2:1	C	A3:3	A2:1	A2:1	C4:1	A1:1	P1:1	A1:2				
				es7	es62	es61	es53	es52	es51	es43	es42	es41	es3	es24	es23	es22	es21	es13	es12	es11				
				94*	92*	91*	90*	89*	88*	87*	86*	85*	84*	83*	82*	81*	80*	79*	78*	77*				
				Can.	Murc	Andal.	Balrs	C.Val	Catal.	Extram	C.Man	C.Leon	Madrid	Aragn	Rioja	Nav	P.Vas	Cant	Aust	Gal				

← 1997

* Indicates the region to which the others are compared.

Source: Author's own research.

hand corner to the left. An index value approaching zero indicates that the industry structures in the regions being compared have converged, i.e. evolved to become increasingly similar. However, the opposite is true when the index values move towards the value of two at the upper end indicating divergence, i.e. complete dissimilarity.

The analysis consists of two steps: first, the regions with the lowest index value are identified and examined for the effects of integration on region-pairs. If region-pairs change, then the compositions of industry structures have changed. Second, the extent to which manufacturing structures within the CAP cluster of regions have become more similar will be examined.

The first step in the analysis employs Table 5.7 to identify the region-pairs with the lowest index value and thus the most similar industry structure. For example, in 1989 there appears to be a very similar industry structure between the two non-adjacent periphery regions of Galicia in the northwest and Andalucia in the south of Spain. The index indicates a value of 0.44, which is the lowest value for both of these regions.

On the other hand, for the periphery region of Asturias, the lowest index value (0.96) is found between it and the adjacent region of Castilla Leon. The industry structure between Asturias and the other Spanish regions show divergence since the index value exceeds unity. The two geographically separated core regions of Madrid and Cataluna show a similarity value of 0.29. Since this is the lowest value for all of the Spanish regions, it indicates that their industry structures are very similar. Subsequent to economic integration, this value changed to 0.90, which indicates a divergence in their industry structures. This implies either a dispersion of existing industries from one of the two regions, or that agglomeration forces have been relatively stronger in one of the regions. Furthermore, it indicates that a substantial change has occurred in the composition of the industry complex in the two agglomerates. This transformation suggests a relocation of and/or entry of supplier and final goods industries.

Table 5.8 lists the pairs of Spanish regions with the lowest index values for the two time periods 1989 and 1997. The country has been divided into north and south, with Madrid in the middle. When comparing those regions that were most similar in 1989 to the region with the most similar industry structure in 1997, not one pair of regions remained the same. In other words, industry restructuring after integration created new region-pairs.

In 1989, there were five pairs of adjoining regions with varying similarity values in their industry structure. The most dissimilar structure existed between the northern periphery region of Asturias and its adjacent region of Castilla Leon, while a strong similarity appears to exist between a cluster of the three southern periphery regions of Extremadura, Andalucia, and Murcia. The most similar industry structure exists between the core regions of Madrid and Cataluna. The remaining region pairs showing similar industry structures are geographically separated from each other. For example, the periphery region of Galicia in the north is similar to the periphery region of Andalucia in the south, while the southern adjacent region of Communidad Valencia is similar to the northern adjacent region of La Rioja. Aragon is similar to Madrid, and not its contiguous core region of Cataluna. Cataluna and its immediate adjacent regions of Communidad Valencia and Aragon do not have a similar industry structure. In 1989, there was only one core-adjacent region combination with a similar industry structure, namely, the northern regions of Pias Vasco and Cantabria.

TABLE 5.8
INDUSTRY STRUCTURE SIMILARITY

REFERENCE REGION	1989	Index	1997	Index
(1)	(2)	(3)	(4)	(5)
Galicia (P, N) -	Andalucia	0.44	Communidad Valencia (A, S)	0.32
Asturias (P, N) -	Castilla Leon*	0.96	Murcia (P, S)	0.38
Cantabria (A, N) -	Navarra	0.41	Pias Vasco (C, N)*	0.68
Pias Vasco (C, N) -	Cantabria*	0.55	Galicia (A, N)	0.50
Navarra (A, N) -	Cantabria	0.41	Pias Vasco (C, N)*	0.62
La Rioja (A, N) -	Communidad Valencia	0.31	Madrid (C, M)	0.38
Aragon (A, N) -	Madrid	0.40	Andalucia (P, S)	0.45
Madrid (C, M) -	Cataluna	0.29	La Rioja (A, N)	0.38
Castilla Leon (A, N) -	Navarra	0.49	Communidad Valencia (A, S)	0.40
Castilla La Mancha (A, S) -	La Rioja	0.32	Murcia (P, S)*	0.47
Extramadura (P, S) -	Andalucia*	0.38	Asturias (P, N)	0.48
Cataluna (C, N) -	Madrid	0.29	Murcia (P, S)	0.46
Communidad Valencia (A, S) -	La Rioja	0.31	Galicia (A, N)	0.32
Baleares (IP, S) -	Castilla La Mancha	0.52	Aragon (A, N)	0.48
Andalucia (P, S) -	Murcia*	0.36	Aragon (A, N)	0.45
Murcia (P, S) -	Andalucia	0.36	Canarias (IP, S)*	0.29
Canarias (IP, S) -	Murcia*	0.53	Murcia (P, S)*	0.29

Legend: C = core; A = adjacent; P = periphery; N = North; S = South; M = Middle; and * = adjoining
Source: Authors own calculations.

MAP 1
ADMINISTRATIVE REGIONS OF SPAIN, PORTUGAL, AND FRANCE

Source: European Commission. Map by Lovell Johns-Whitney.

Due to its connectivity with the core region of Norte in Portugal, Galicia was reclassified as an adjacent region in 1997. After integration, the adjacent region of Galicia in the north, and the northern periphery region of Asturias, evolved to have industry structures similar to that of the adjacent region of

Communidad Valencia and the periphery region of Murcia in the south respectively. In the north, the core region of Pias Vasco obtained a more similar industry structure to that of its two adjoining-regions of Cantabria and Navarra. However, Pias Vasco shows greater similarity with Galicia than it does with its immediate adjacent regions. Aragon in the north became more similar to Andalucia and Baleares in the south, while the industry structure of Madrid became very similar to that of La Rioja in the north. In the south, the two connecting regions of Castilla La Mancha and Murcia show a strong similarity with the island periphery region of Canarias in the Northwest.

Based on these findings, the analysis reveals that the industry structures between regions have changed as a result of the forces of economic integration. However, since the effect of integration on the industry structures of contiguous regions is under study, it is necessary to examine the changing indexes within the framework of the CAP clusters. Doing so will facilitate a determination of whether industry structures of adjoining regions have converged or diverged.

5.6.1.2 The Industry Index Within the CAP Framework

The industry index can be used to evaluate the extent to which regions in a CAP cluster have converged or diverged. The CAP regions are listed in Table 5.9a. The region codes are listed in column (1). These codes are used in column (6) to indicate regional connectivity according to the CAP model. The region codes in columns (3) and (4) refer to the foreign bordering regions. The values of the industry index of Table 5.9 for 1989 have been placed in Table 5.9b and those of 1997 in Table 5.9c. These two tables reflect the industry structures before and after economic integration in 1992. In Table 5.9d, the size of the change in the regional index values between 1989 and 1997 are listed.

The CAP model assumes that a core region functions as an attraction or dispersion region for industry. If the core functions as an attraction region, then one would expect a dissimilar industry index value between the core and its adjacent and periphery regions. If, on the other hand, the core region functions as a dispersion region, then one would expect the industry index values to become more similar. The latter would lead to the conclusion that a convergence of industry structures is occurring between contiguous regions, specifically between a core and its adjacent region. The index values in Table 5.9b and Table 5.9c facilitate a comparison of industry structures within the framework of the CAP model. A general comparison of the two tables illustrate that economic integration has eliminated all of the industry index values greater than unity. This result suggests a convergence of regional industry structures.

CAP Cluster Pias Vasco

The CAP cluster of Pias Vasco consists of the following core, adjacent, and periphery regions. The core region of Pias Vasco is surrounded by three adjacent regions; Cantabria in the west, Navarra in

TABLE 5.9
CHANGES IN THE INDUSTRY INDEX OF SIMILARITY / DIVERSITY

TABLE 5.9.a

(1)	(2)	(3)	(4)	(5)	(6)								
	SPAIN 17			CAP-REGIONS									
ES11	64 Galicia		PT11	A1:2	ES41	ES12	ES21						
ES12	65 Asturias			P1:1	ES13	ES41	ES11	ES21					
ES13	66 Cantabria			A1:1	ES21	ES41	ES12						
ES21	67 Pias Vasco		FR61	C4:1	ES13	ES41	ES23	ES22					
ES22	68 Navarra		FR61	A2:1	ES21	ES23	ES24						
ES23	69 Rioja			A2:1	ES21	ES22	ES24	ES41					
ES24	70 Aragon	FR62	FR61	A3:3	ES51	ES22	ES23	ES41	ES42	ES52			
ES3	71 Madrid			C	ES41	ES42							
ES41	72 Castillia-Leon	PT12	PT11	A2:1	ES3	ES21	ES13	ES23	ES24	ES42	ES11	ES12	ES43
ES42	73 Cast.-La Mancha			A3:5	ES3	ES41	ES61	ES62	ES52	ES24	ES43		
ES43	74 Extremadura	PT12	PT14	P3:2	ES41	ES42	ES61	ES3					
ES51	75 Cataluna	FR62	FR81	C4:1	ES24	ES52							
ES52	76 Com. Valenciana			A1:2	ES51	ES24	ES42	ES62					
ES53	77 Baleares (Island)			IP1:2	ES52	ES51							
ES61	78 Andalucia			P1:3	ES42	ES3	ES43	ES62					
ES62	79 Murcia			P2:1	ES42	ES3	ES52	ES61	ES51				
ES7	81 Canarias (Island)			IP1:2	ES11	ES12							

TABLE 5.9.b

		REGIONAL INDUSTRY SIMILARITY INDEX 1989											
ES11	64 Galicia		PT11	P1:2	0.51	1.03	1.01						
ES12	65 Asturias			P1:1	1.00	0.96	1.03	1.09					
ES13	66 Cantabria			A1:1	0.54	0.51	1.00						
ES21	67 Pias Vasco		FR61	C4:1	0.55	1.00	0.94	0.66					
ES22	68 Navarra		FR61	A2:1	0.66	0.59	0.42						
ES23	69 Rioja			A2:1	0.94	0.59	0.66	0.63					
ES24	70 Aragon	FR62	FR61	A3:3	0.45	0.42	0.66	0.51	0.70	0.65			
ES3	71 Madrid			C	0.64	0.79							
ES41	72 Castillia-Leon	PT12	PT11	A2:1	0.64	1.00	0.51	0.63	0.51	0.63	0.51	0.96	0.74
ES42	73 Cast.-La Mancha			A3:5	0.79	0.63	0.45	0.49	0.45	0.70	0.45		
ES43	74 Extremadura	PT12	PT14	P3:2	0.74	0.45	0.38	0.92					
ES51	75 Cataluna	FR62	FR81	C4:1	0.45	0.61							
ES52	76 Com. Valenciana			A1:2	0.61	0.65	0.45	0.57					
ES53	77 Baleares (Island)			IP1:2	0.58	1.02							
ES61	78 Andalucia			P1:3	0.45	0.75	0.38	0.36					
ES62	79 Murcia			P2:1	0.49	0.80	0.57	0.36	0.85				
ES7	81 Canarias (Island)			IP1:2	0.57	1.17							

TABLE 5.9.c

		REGIONAL INDUSTRY SIMILARITY INDEX 1997											
ES11	64 Galicia		PT11	A1:2	0.41	0.49	0.50						
ES12	65 Asturias			P1:1	0.78	0.72	0.49	0.63					
ES13	66 Cantabria			A1:1	0.68	0.93	0.78						
ES21	67 Pias Vasco		FR61	C4:1	0.68	0.69	0.53	0.62					
ES22	68 Navarra		FR61	A2:1	0.62	0.64	0.85						
ES23	69 Rioja			A2:1	0.53	0.64	0.67	0.70					
ES24	70 Aragon	FR62	FR61	A3:3	0.69	0.85	0.67	0.75	0.49	0.66			
ES3	71 Madrid			C	0.56	0.57							
ES41	72 Castillia-Leon	PT12	PT11	A2:1	0.56	0.69	0.93	0.70	0.75	0.78	0.41	0.72	0.84
ES42	73 Cast.-La Mancha			A3:5	0.57	0.78	0.70	0.47	0.40	0.49	0.63		
ES43	74 Extremadura	PT12	PT14	P3:2	0.84	0.63	0.62	0.73					
ES51	75 Cataluna	FR62	FR81	C4:1	0.69	0.91							
ES52	76 Com. Valenciana			A1:2	0.91	0.66	0.68	0.70					
ES53	77 Baleares (Island)			IP1:2	0.59	0.88							
ES61	78 Andalucia			P1:3	0.70	0.91	0.62	0.54					
ES62	79 Murcia			P2:1	0.47	0.67	0.70	0.54	0.46				
ES7	81 Canarias (Island)			IP1:2	0.46	0.60							

TABLE 5.9

CHANGES IN THE INDUSTRY INDEX OF SIMILARITY / DIVERSITY

TABLE 5.9.d

					CHANGES IN INDUSTRIAL REGIONAL STRUCTURES 1989 - 1997								
ES11	64 Galicia		PT11	A1:2	-0.10	-0.54	-0.51						
ES12	65 Asturias			P1:1	-0.21	-0.25	-0.54	-0.46					
ES13	66 Cantabria			A1:1	0.14	0.42	-0.21						
ES21	67 Pias Vasco		FR61	C4:1	0.13	-0.30	-0.40	-0.04					
ES22	68 Navarra		FR61	A2:1	-0.04	0.05	0.43						
ES23	69 Rioja			A2:1	-0.40	0.05	0.01	0.07					
ES24	70 Aragon	FR62	FR61	A3:3	0.24	0.43	0.01	0.23	-0.21	0.00			
ES3	71 Madrid			C	-0.08	-0.22							
ES41	72 Castillia-Leon	PT12	PT11	A2:1	-0.08	-0.30	0.42	0.07	0.23	0.15	-0.10	-0.25	0.11
ES42	73 Cast.-La Mancha			A3:5	-0.22	0.15	0.25	-0.02	-0.05	-0.21	0.18		
ES43	74 Extremadura	PT12	PT14	P3:2	0.11	0.18	0.24	-0.19					
ES51	75 Cataluna	FR62	FR81	C4:1	0.24	0.29							
ES52	76 Com. Valenciana			A1:2	0.29	0.00	0.23	0.13					
ES53	77 Baleares (Island)			IP1:2	0.01	-0.15							
ES61	78 Andalucia			P1:3	0.25	0.16	0.24	0.18					
ES62	79 Murcia			P2:1	-0.02	-0.13	0.13	0.17	-0.39				
ES7	81 Canarias (Island)			IP1:2	-0.11	-0.57							

Source: Author's own research

the south, and La Rioja in the east. The periphery regions belonging to this cluster are Asturias and Galicia in the west.

The industry structure between Pias Vasco and its adjacent regions of La Rioja, and Navarra have converged, as has the index value between Pias Vasco and Castilla Leon. In contrast to this, there was a divergence in industry structure between Pias Vasco and its adjacent region of Cantabria. There is also a significant convergence between Pias Vasco and its periphery region of Asturias. Specifically, the index value changed from 1.09 in 1989 to 0.63 in 1997. With the exception of Cantabria, the regions in the CAP cluster of Pias Vasco demonstrated a convergence in their industry structures. Furthermore, the adjacent regions of Pias Vasco showed a stronger convergence with their core region than with the adjoining regions of a different CAP cluster. In this case, there was a marginal divergence of structures.

For example; La Rioja and Aragon remained almost constant at 0.66 in 1989 and 0.67 in 1997; La Rioja showed a divergence from Castilla Leon from 0.63 in 1989 to 0.67 in 1997. There was a divergence between adjacent region of Navarra and Aragon from 0.42 in 1989 to 0.85 in 1997. The periphery region of Asturias exhibited a pronounced strong reversal in its industry structure with four regions; Asturias – Cantabria from 1.0 to 0.78; Asturias – Castilla Leon from 0.96 to 0.72; Asturias – Galicia from 1.03 to 0.49; and finally, Asturias – Pias Vasco from 1.09 to 0.63.

Finally, in this cluster the *ex ante* periphery region of Galicia displays a significant convergence of industry structure with its periphery region of Asturias, as well as with its core region of Pias Vasco between 1989 and 1997. (Galicia – Asturias from 1.03 to 0.49, and Galicia – Pias Vasco from 1.01 to 0.50). There is also some convergence between the adjoining region of Castilla Leon, which belongs to the Madrid cluster. This strong convergence of industry structure in Galicia with the other regions in its cluster can to a large extent, be explained by its geographic border position with the Portuguese core region of Norte. In fact, this development is a prime example of the operation of the dispersion effect in a border region, due to trade liberalisation with a foreign core region (Krugman and Venables, 1996)

CAP Cluster Cataluna

The CAP cluster of Cataluna is composed of the following adjacent regions: Aragon in the west and Communidad Valencia in the south. In addition to these adjacent regions, the periphery region of Murcia belongs to this cluster.

The index values reveal that the core region of Cataluna diverged in industry structure from both its adjacent regions. Specifically, it became more dissimilar from Aragon, increasing from 0.45 in 1989 to 0.69 in 1997, and for Communidad Valencia from 0.61 in 1989 to 0.91 in 1997. In contrast, the industry structure between Aragon and Communidad Valencia remained constant. This consistency is demonstrated by the similarity in index values, changing from 0.65 in 1989 to 0.66 in 1997. However, it showed a divergence in industry structure with all other contiguous regions. Similarly, the industry structure of Aragon diverged from all its adjoining regions in 1997, with the exception of Castilla La-

Mancha where the change from 0.70 in 1989, to 0.49 in 1997 indicates that a convergence occurred between these two regions.

It is of interest to note that the periphery region of Murcia displayed a relatively strong convergence with its core region of Cataluna. In fact, the index value changed from 0.85 in 1989, to 0.46 in 1997. Murcia, on the other hand, exhibited a growing dissimilarity with the adjoining regions of Castilla La-Mancha and Andalucia, both belonging to the CAP cluster of Madrid. Based on these findings, we can conclude that agglomeration forces dominated between the core region of Cataluna and its adjacent regions. This divergence of industry structures between the core and its adjacent regions, from that of 1989 indicates a recomposition of industry structures in these regions. In addition to this, we can conclude that the competition effect was strong between Cataluna and its periphery region of Murcia. It must be noted that some convergence occurred between Murcia and the core region of Madrid.

CAP Cluster of Madrid

The CAP cluster of Madrid consists of four regions. The two large adjacent regions of Castilla Leon and Castilla La Mancha surround the core region of Madrid. Contiguous to these adjacent regions are the two periphery regions of Andalucia and Extremadura.

A comparison of the index values reveals that the industry structures between Madrid and its two adjacent regions became nearly identical (respectively 0.56 and 0.57). Of the two adjacent regions, Castilla La Mancha experienced the most significant change. On the other hand there is a strong divergence of industrial structures between Madrid and its two periphery regions of Extremadura and Andalucia. The subsequent analysis of changes industry concentration should reveal the cause of this structural change. Andalucia, however, does show a strong historical affinity with the periphery region of Murcia. The industry structures converged marginally from 0.49 in 1989, to 0.47 in 1997.

5.6.1.3 Conclusions on Industry Structure

This analysis sheds light on the fact that trade liberalisation influenced the (re) location of firms (n) and employment (L) within the CAP clusters that altered the industry structures between regions. The outcomes for the CAP clusters of Pias Vasco and Madrid reveal a dispersion of industry, which led to a convergence of industrial structures with their respective core and adjacent regions. In contrast to the manner in which these CAP clusters evolved, the CAP cluster of Cataluna witnessed a divergence in industrial structure between the core and adjacent regions.

In those instances in which core and adjacent regions became more similar, it can be concluded that either; firms within industries dispersed to regions that already possessed an initial level of a particular industry (Forslid *et.al.,* 1999), new firms entered into existing industries (clustering) because of economic profits (Krugman, 1991b), and/or new industries located in new regions, such as office machinery and computers in the adjacent region of Navarra, and new industries in the Energy sector locating in the core region of Madrid. In the case of Cataluna, it must be concluded that agglomeration forces dominated in industry relocation because of its *ex post* divergent industrial structure versus its adjacent regions (Krugman, 1991b). Given Cataluna's favourable geographic distance from the EU geographic core, this development in Cataluna could be evidence of regional industry specialisation (Krugman and Venables, 1996).

In 1989, Spain counted five periphery regions of which only one, Andalucia, showed an *ex post* divergence in industry structure with its core region while the remaining regions experienced a convergence. The periphery regions of Andalucia, Extremadura, and Murcia all show an *ex post* divergent production structure from their adjoining regions. Forslid and Wooton, (1999), and Forslid *et al.*, (1999) have argued that this divergence could be caused by the location of industries seeking comparative advantage, or as Venables (2000) would argue, industries with low demand elasticities, and low transport intensities seeking a high return on capital investments. Only the two northwestern periphery regions of Asturias and Galicia experienced a convergence of industry structures with all of their adjoining regions. These two regions experienced the largest swings from dissimilarity to similarity.

The explanation for the magnitude of these swings is two pronged. To begin with, the border periphery region of Galicia enjoyed the complete benefits of trade liberalisation with the Portuguese core region of Norte. The removal of trade barriers between countries encouraged industrial growth in Galicia (Krugman and Venables, 1996). In addition to this, the improvement of road infrastructure, from Galicia along the northern Spanish coast benefited the geographic location of Asturias as a conduit between Galicia[67] and the core region of Pias Vasco. This development is informative, since it reflects the working of trade liberalisation and domestic infrastructure improvements. This case exemplifies the fact that the competition effect dispersed industries to take advantage of the wage differential favouring the periphery regions (Venables, 1994).

Finally, the three CAP clusters verify the historical existence of a divergent multi-agglomerate production structure in Spain where trade liberalisation served as a catalyst for strong convergent industry developments between core and adjacent regions. The polycentric structure of Spain is evidenced by the duplication of northern industry structures in the southern regions of Extremadura, Commanded Valencia, Andalucia, and Baleares. This implies that industries have relocated, but are not highly localised, and that trade liberalisation did not destabilise the original centres of production (Krugman and Venables, 1996). Trade liberalisation did, however, result in a recomposition of industry structures and industry concentration.

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[67] The region of Galicia on the west coast has four airfields; two in the urban area La Corunna, and two in the urban area Vigo. Both urban areas have Atlantic coast harbours. The core region of Pias Vasco has two airfields.

5.7 INDUSTRY CONCENTRATION

Trade liberalisation induces a relocation of manufacturing concentration (Krugman and Venable, 1996). The empirical literature uses the location-Gini to measure the concentration of manufacturing activity (Krugman, 1991a; Brülhart and Torstensson, 1996; Midelfart *et. al.*, 2000). The empirical literature also suggests that one single concentration measure, such as the location-Gini, does not capture the difference in size between countries (Haaland *et. al.*, 1999), and point to the need for relative and absolute concentration measurements, such as those developed by Amiti (1997) and Forslid (1999). Relative concentration indicates comparative advantage and specialisation in production, while economic geography agglomeration effects are measured by absolute concentration (Haaland *et. al.*, 1999; Forslid, *et.al* 1999). The relative and absolute industry concentration measures apply to industry at the country level, and not the regional level.

This study examines industry concentration at the regional level and therefore needs a measurement that identifies the region in which an industry is concentrated. The location-Gini satisfies this requirement. However, the disadvantage of the location-Gini is that it is a relative measurement and simply measures comparative advantage. This section has three objectives; one, to examine industry concentration with the use of the location-Gini; two, to illustrate the disadvantage of the relative and absolute concentration measurements at the regional level; and, three to develop a new regional absolute and relative concentration measure. This is a new measure in economic geography that singularly measures both absolute and relative concentration by relating regional manufacturing employment per industry to the region's geographic size.

5.7.1 The Manufacturing Employment Location-Gini.

The manufacturing employment location Gini[68] is a measure of industry concentration and/or dispersion. This ratio measures the concentration of industry *i* in the *j* regions of a country. The ratio is defined and calculated as follows;

$$LG_{ij} = \frac{RS_{ij}^{ei}}{(RS_{ij}^{ei} + RS_{j}^{me})} \tag{5.2}$$

where, RS_{ij}^{ei} is the region's share of national employment in industry *i*, and RS_{j}^{me} is the region's share of national manufacturing employment. The values of these ratio's are such that $0 \leq RS_{ij}^{ei} < 1$, $0 \leq RS_{j}^{me} < 1$ so that $0 \leq LG_{ij} \leq 1$, , with $\sum_{i=1}^{I} RS_{ij}^{ei} = 1$ and $\sum_{i=1}^{I} RS_{ij}^{me} = 1$. A value of $LG_{ij} = 0.5$ means that ($RS_{ij}^{ei} = RS_{j}^{me}$) the region's share of employment in industry *i* equals the region's share of total national manufacturing

[68] The choice of this ratio is discussed in Appendix 2A of Chapter 2.

employment, whereas $0.5 \leq LG_{ij} \leq 1$ means that $RS_{ij}^{ei} > RS_{j}^{me}$. An increase in the value of an $LG_{i,j}$-coefficient over time means a regional increase in manufacturing employment in industry *i*..

The location-Gini is a concentration measure that relates a region's share of employment in industry *i* to a region's share in total manufacturing employment. It is therefore a measure of relative concentration and, as such, a measure of comparative advantage and specialisation (Haaland *et. al.*, 1999). The location-Gini addresses two questions regarding the effects of trade liberalisation. First, which industries have been affected by an interregional relocation and concentration of firms and manufacturing employment? Second, has industry become more concentrated or more dispersed?

The location-Gini coefficients were estimated using regional manufacturing employment data. Estimates of the location-Gini coefficients per industry sector for 1989 and 1997 can be found in Table 5A.4 (Chapter 5, Appendix 5A). The regions are ranked in descending order according to the location-Gini value for industry *i* in each region *j*. In Table 5.10, a summary is provided of those industries showing a change in concentration according to whether the employment location-Gini increased, decreased or remained constant.

TABLE 5.10

EMPLOYMENT LOCATION GINI: CHANGES IN INDUSTRY CONCENTRATION 1997 AND 1989

	1997	1989		1997	1989
Increased Concentration (CC)			*Decreased Concentration (CLC)*		
Quarrying and Mining Energy Materials	0.953	0.940	Basic Metal products	0.858	0.888
Leather & Leather Products	0.809	0.665	Office Machinery & Computers	0.781	0.867
Wearing Apparel	0.785	0.731	Coke, refinery, & Nuclear	0.762	0.908
Electricity, Gas and Steam	0.781	0.751	Purification and Distribution of Water	0.747	0.765
Other Transport	0.775	0.766	Machinery & Equipment	0.693	0.711
Motors and Trailers	0.747	0.690	Fabricated Metal Products	0.686	0.699
Medical Precision Instruments	0.723	0.670	Textiles	0.685	0.729
Food, Beverage & Tobacco	0.711	0.695	Manufacture of Jewellery & Music Instr.	0.658	0.680
Electrical Machinery & Apparat.	0.690	0.651	Rubber and Plastics	0.638	0.657
Wood products	0.688	0.636			
Non-Metallic Minerals	0.662	0.659	*No Change in Concentration (NC)*		
Chemicals & Man Made Fibres	0.643	0.630	Quarrying & Mining Non-Energy Materials	0.762	0.762
			Paper & Paper Products	0.707	0.707

Source: Author's own calculations taken from Table 5B.4, Chapter 5, Appendix 5B. *CC* = increased concentration; *CLC* = concentrated becoming less concentrated; *NC* = no change in concentration

The estimations show that industry concentration increased in twelve industries, declined in nine, and remained unchanged in two. Employment relocation affects the comparative advantage position of industries in specific regions within the CAP clusters. In Table 5.11, regions with the highest employment location-Gini are categorised into their CAP clusters revealing the changing relative regional concentration of industry between 1997 and 1989. The analysis reveals that the relative concentration of industry changed regions in nine of the twelve industries. Average industry concentration has increased in the CAP clusters of Madrid and Cataluna, but declined in the CAP cluster of Pias Vasco. These results verify the relocation of employment outcomes of the previous section. The data also shows a dispersion of industry across different region types, and verifies the multi-agglomerate production outcome found in the industry index analysis.

TABLE 5.11
CAP-CLUSTERS: CHANGES IN GEOGRAPHIC LOCATION OF INDUSTRY CONCENTRATION

	IS	R	LG 1997			IS	R	LG 1989	
Pias Vasco					*Pias Vasco*				
Quarrying and Mining of Energy Materials (CA)	E	1	0.953	Asturias (P)	Quarrying and Mining of Energy Materials (CA)	E	1	0.940	Asturias (P)
Basic Metal products (DJ27)	EN	2	0.858	Asturias (P)	Coke, Refinery, and Nuclear (DF)	E	2	0.908	Canarias (IP)
Other Transport (DM35)	EN	7	0.775	Galicia (A)	Basic Metal products (DJ27)	EN	3	0.888	Asturias (P)
Motors and Trailers (DM34)	EN	9	0.747	Navarra (A)	Other Transport (DM35)	EN	5	0.766	Galicia (A)
Purification and Distribution of Water (E41)	E	9	0.747	La Rioja (A)	Purification and Distribution of Water (E41)	E	6	0.765	Canarias (IP)
Food, Beverages, and Tobacco (DA)	OM	11	0.711	Canarias (IP)	Quarrying and Mining of Non-Energy Materials (CB)	EP	7	0.762	Galicia (A)
Machinery and Equipment (DK)	EN	13	0.693	Pias Vasco (C)	Electricity, gas and Steam (E40)	E	8	0.751	Canarias (IP)
Wood products (DD)	OM	15	0.688	Galicia (P)	Machinery and Equipment (DK)	EN	11	0.711	Pias Vasco (C)
Fabricated Metal products (DJ28)	EN	16	0.686	Pias Vasco (C)	Fabricated Metal products (DJ28)	EN	13	0.699	Pias Vasco (C)
Rubber and Plastics (DH)	EP	21	0.638	Pias Vasco (C)	Rubber and Plastics (DH)	EP	20	0.657	Pias Vasco (C)
Average			0.750		*Average*			0.785	
Madrid					*Madrid*				
Wearing Apparel (DB18)	OM	4	0.785	C. La Mancha (A)	Wearing Apparel (DB18)	OM	9	0.731	C. La Mancha (A)
Office Machinery and Computers (DL30)	EN	6	0.781	Madrid (C)	Paper and paper products (DE)	OM	12	0.707	Madrid (C)
Quarrying and Mining of Non-Energy Materials (CB)	EP	8	0.762	Extremadura (P)	Food, Beverages, and Tobacco (DA)	OM	14	0.695	Extremadura (P)
Coke, Refinery, and Nuclear (DF)	E	8	0.762	C. La Mancha (A)	Motors and Trailers (DM34)	EN	15	0.690	C. Leon (A)
Medical Precision Instruments (DL33)	EN	10	0.723	Madrid (C)	Electrical Machinery and Apparature (DL31)	EN	21	0.651	Madrid (C)
Paper and paper products (DE)	OM	12	0.707	Madrid (C)					
Average			0.753		*Average*			0.695	
Cataluna					*Cataluna*				
Leather and Leather products (DC)	OM	3	0.809	Com.Valencia (A)	Office Machinery and Computers (DL30)	EN	4	0.867	Baleares (IP)
Electricity, gas and Steam (E40)	E	5	0.781	Baleares (IP)	Textiles (DB17)	OM	10	0.729	Cataluna (C)
Electrical Machinery and Apparature (DL31)	EN	14	0.690	Aragon (A)	Manufacturing of jewelry and Musical (DN)	OM	16	0.680	Baleares (IP)
Textiles (DB17)	OM	17	0.685	Cataluna (C)	Medical Precision Instruments (DL33)	EN	17	0.670	Cataluna (C)
Non-Metallic Minerals (DI)	EP	18	0.662	Com. Valencia (A)	Leather and Leather products (DC)	OM	18	0.665	Com. Valencia (A)
Manufacturing of jewelry and Musical (DN)	OM	19	0.658	Baleares (IP)	Non-Metallic Minerals (DI)	EP	19	0.659	Com. Valencia (A)
Chemicals and Man Made Fibres (DG)	EP	20	0.643	Cataluna (C)	Wood products (DD)	OM	22	0.636	Murcia (IP)
					Chemicals and Man Made Fibres (DG)	EP	23	0.630	
Average			0.704		*Average*			0.667	
National Average			0.737		*National Average*			0.733	

IS = Industrial Sector; E = Energy; EP = Extraction and Processing; EN = Engineering; OM = Other Manufacturing; R = Industry Ranking; and LQ = Location Quotient

Source: Author's own research

The appeal of the location-Gini method of measuring relative industry concentration is that it ranks industries per region, and allows for an analysis of regional changes in employment concentration. However, the location-Gini does not distinguish between absolute and relative concentration. The relative concentration value of a location-Gini coefficient is defined as a value in the range $0.5 \leq LG_{ij} \leq 1$. A coefficient value $L_{ij} = 0.5$ means that the share of regional manufacturing employment equals the regions share of employment in a particular industry. The calculation method does not allow for an objective demarcation of relative and absolute values in the range $0.5 \leq LG_{ij} \leq 1$.

In concluding, the employment location-Gini is a measure of relative concentration, but only reveals a region's comparative advantage in manufacturing employment in a particular industry. The industry concentration outcomes support the conclusions of the industry index analysis that core and adjacent regions appear to have become more similar in their industry structure through the dispersion of particular industries. The disadvantage of the location Gini is that it provides no information about the absolute concentration of industry.

5.7.2 Relative and Absolute Industry Concentration

The results of the location-Gini measurements support the findings of the industry index analysis that a polycentric production structure exists in the core clusters of the Spanish regions. The advantage of the location-Gini coefficient is that it provides information at the regional levels. The Amiti (1997) relative concentration measure indicates relative industry dispersion at the national level. Amiti's relative concentration ratio takes the following form:

$$S_i^R = \sqrt{\frac{1}{c}\sum_j (s_{ij} - s_j)^2} = \sqrt{\frac{1}{c}\sum_j \left(RS_{ij}^{ei} - RS_j^{me}\right)^2} \tag{5.3}$$

where, region j's share of manufacturing employment in industry i is measured by $s_{ij} = RS_{ij}^{ei}$; region j's share in total national manufacturing employment is represented by $s_j = RS_j^{me}$; and c is the total number of regions. The relative concentration ratio takes into consideration a region's size as measured by s_j. The dimension size refers to the total manufacturing labour force in the region, but not the region's geographic area. A value of $S_i^R > 1$ indicates that an industry is relatively concentrated indicating comparative advantage and specialization.

Amiti's relative concentration index measures the concentration of individual industries *within* a country. The relative concentration values for Spain are found in columns (2) and (4) of Table A.5.5. Amiti's (1997) relative concentration measures provide information for only three industries that have increased their relative concentrations. In 1989, the industry quarrying and mining of energy materials showed the highest relative concentration ratio followed by basic metal products, and textiles. In 1997, relative concentration of quarrying and mining increased, followed by leather and leather products, and office machinery and computers. The disadvantage of the measurement is that it is countrywide, not region specific, and provides no information on a regional basis. The location-Gini and the Amiti relative concentration index differ in their ranking of industries, with the exception of the industry quarrying and mining of energy materials.

Amiti's (1997) absolute concentration index is a measure for economies of scale and trade (Haaland *et. al.*, 1999). It takes on the form:

$$S_i^A = \sqrt{\frac{1}{c}\sum_j (s_{ij})^2} = \sqrt{\frac{1}{c}\sum_j \left(RS_{ij}^{ei}\right)^2} \tag{5.4}$$

where $s_{ij} = RS_{i,j}^{ei}$. A value of $S_i^A > 1$, implies that an industry is highly concentrated and dependent on economies of scale. The disadvantage of this measurement is that it too is one for industry and does not identify the regions in which industry concentration increased or declined. It does not allow for the regional geographical location of industry concentration.

The estimated values for Amiti's absolute concentration index are found in columns (8) and (10). Industries that became more concentrated (*CC*) are; leather and leather products, office machinery and equipment, and chemicals and man made fibres. Industries that were concentrated in 1989 but have become less concentrated (*CLC*) are; quarrying and mining of energy materials, textiles, medical precision instruments, and electrical machinery and apparatus. Industries that were concentrated in 1989 and become dispersed (*CD*) are; basic metal products, and coke, refinery and nuclear energy. The industry that was dispersed and has become more concentrated (*DC*) is paper and paper products. This measure is also country specific and provides no information over regional manufacturing concentration. The Amiti absolute measures cannot be compared to the location-Gini because of their differences in measurement procedure.

Forslid *et al.*, (1999) have developed an absolute industry concentration measure that is defined by the following expression:

$$C_i = \sqrt{\sum_j \left(s_{ij} - \bar{s}_{ij}\right)^2 / N} = \sqrt{\sum_j (RS_{ij}^{ei} - R\bar{S}_{ij}^{ei})^2 / N} \tag{5.5}$$

The empirical results of the Forslid *et al.*, (1999) concentration measure are found in Table 5A.5, columns (14) and (16). The Forslid method shows no industries in the (*CC*) category. In the (*CLC*) category we find the two industries quarrying and mining of energy materials, and textiles. In the (*DC*) category are; leather and leather products, office machinery and computers, and chemicals and man made fibres. The (*CD*) category consists of the industry medical precision instruments. These outcomes are inconsistent with the Amiti (1997) absolute concentration measurement outcomes. This industry measure is also not region specific and does not allow for the identification of the region and/or adjoining regions in which a particular industry is concentrated.

The common disadvantage of these concentration measurements can be overcome by looking at the individual regional statistical measures used in the calculation of the Forslid *et.al.*,(1999) absolute concentration measure. For example, for the j^{th} region a relevant statistic is defined as $(RS_{ij}^{ci} - \overline{RS}_{ij}^{ci})^2$. The j^{th} region, with the relatively highest value for this statistic, is assumed to have the highest concentration in industry *i*. Although this method allows for identification of geographic locations of industry, the statistical value is different from the final concentration measurement. This method is used to identify the regions for both the Amiti and Forslid absolute concentration measurements. The regions are listed in column (12) and column (17) respectively. It is important to note that, for both the Amiti (1997) and Forslid *et.al.*, (1999) calculations, the region ranking remains the same, but the regions are not directly correlated to the absolute concentration measurement.

5.7.3 A Standardised Relative and Absolute Concentration Measurement

Haaland *et. al.*, (1999) emphasise the necessity of considering country size in the choice of a concentration measure. The authors argue that 'an industry is *relatively* concentrated if it differs from the average spread of production between countries [regions]; it has a high degree of *absolute* concentration if it is unevenly distributed between countries [regions].' This study develops a new concentration measure as an alternative to the relative and absolute concentration measurements of Amiti (1997) and Forslid *et al.*, (1999). Their measurements have two disadvantages; one, both are country and not region specific; and, two, neither measurements consider the dimension of actual regional geographic size. The manufacturing employment location-Gini is also suspect of accuracy since it also fails to consider regional geographic size. It is a relative measurement, like that of Amiti (1997), and uses total regional industry employment as the measure of region size.

The new measurement is called the '*labour-land concentration ratio*' that takes into consideration the geographic size of a region. The ratio reveals both relative and absolute regional industry concentration. We calculate a standardised labour-land ratio, L_{ij}, for each industry *i* in region *j* and assume the calculated values represent a standard normal distribution of an industry across the regions. The standard normal distribution of any variable has a mean $\mu = 0.0$ and a standard deviation $\sigma = 1$.

For any standardised variable the null hypothesis assumes that the value of the observation is not significantly different from zero mean i.e. H_0: $\mu_{L_{ij}} = 0.0$. If the null hypothesis cannot be rejected, then the observed value of L_{ij} is not significantly different from its mean value and suggests that the observations are dispersed around the mean. The region with the highest L_{ij} value falling within the area of non-rejection will have the highest *relative* concentration in that industry. Therefore, an industry is relatively concentrated or dispersed between regions if the standard deviation of the labour-land concentration ratio has a positive value around the mean and falls within the area of non-rejection.

The alternative hypothesis states, that the observed value is significantly different from the zero mean i.e. $H_1: \mu_{L_{ij}} \neq 0.0$. If the null hypothesis is rejected and the alternative hypothesis is accepted, then the observed value of L_{ij} falls within the area of rejection, which means that it is significantly different from its mean value with a 0.001 percent chance of falling within the area of non-rejection. The region with the highest L_{ij} value falling in the area of rejection will have the highest *absolute* concentration in that industry. An industry is absolutely concentrated if the concentration ratio falls in the critical rejection area.

An industry can be both absolutely and relatively concentrated, but not in the same region. Regional relative and absolute concentration of an industry is mutually exclusive. The advantage of the labour-land concentration ratio is that it measures the concentration of regional manufacturing employment per industry per square kilometre, thereby eliminating the issue of region size i.e. small versus large regions.

The absolute labour-land concentration measurement is constructed as follows. Let the regional labour-land ratio be defined as follows:

$$l_{ij} = \frac{E_{ij}}{N_j^2} \qquad 0 \leq l_{ij} \leq 1$$

where, E_{ij} is the number of people employed in industry i in region j, and N_j^2 is the geographic area of region j measured in square kilometres. The data is then normalised in the following way:

$$L_{ij} = \frac{l_{ij} - \bar{l}_i}{\sigma_{l_i}} \tag{5.6}$$

where, l_{ij} is the labour-land ratio in industry i in region j; $\bar{l}_i$ is the average labour-land ratio industry i; and σ_{l_i} is the standard deviation of the labour-land ratio industry i. The standardised variable L_{ij} has a mean μ_i = 0, and standard deviation σ_{l_i} = 1. For a standardised normal distribution, 99.38% of all observations lie within ±2.5 standard deviations from the mean, and 99.9% lie within ±3 standard deviations from the mean. By way of summary, a region will have a *relative* concentration in industry i, if $0 < L_{ij} < 3\sigma$, and an *absolute* concentration in industry i, if $L_{ij} > 3\sigma$. The standardised employment values measure industry concentration as a deviation from the mean industry employment value in a particular region.

5.7.4 The *Lij* Concentration Measurement

The standardised normal labour-land concentration ratios per industry sector are categorised in Table 5A.6, Appendix 5A of this chapter. In Table 5.12 below, the industries are grouped[69] into four categories; one, industries that remained concentrated (*CC*); two, dispersed industries that increased their concentration (*DC*); three, concentrated industries that became more dispersed (*CD*); and four, dispersed industries (*DD*) that remained dispersed but experienced a change in their level of concentration.

TABLE 5.12
CHANGES IN REGIONAL INDUSTRY CONCENTRATION: ΔL_{ij}

Increased Concentration (CC)	*(RT)*	*Dispersed More Concentrated (DC)*	*(RT)*
Quarrying & Mining Energy Materials	P	Electricity, Gas & Steam	C
Rubber & Plastics (CLC)	C	Purification & Distribution of Water	C
Basic Metal products	C	Coke, Refinery & Nuclear	C
Fabricated Metal products (CLC)	C	Wearing Apparel	C
Machinery and Equipment	C	Leather & Leather Products	A
Office Machinery & Computers	C		
Medical Precision Instruments	C		
Textiles (CLC)	C		
Paper & Paper Products	C		
Concentrated More Dispersed (CD)		*Dispersed Less/More Dispersed (DD)*	
Chemicals & Man Made Fires	C	Quarrying & Mining Non-Energy (DMD)	A
Motors & Trailers	C	Non-Metallic Minerals (DLD)	A
Other Transport	C	Electrical Machinery & Apparatus (DLD)	C
		Food, Beverages & Tobacco (DMD)	C
		Wood Products (DLD)	A
		Manufacture of Jewellery & Musical (DLD)	C

Source: Author's own research. *RT* = region type; *C* = Core, *A* = Adjacent, *P* = Periphery, and *IP* = Island Periphery.

The nine industries categorised as (*CC*), (*CLC*) and (*CMC*) have an *absolute* concentration value $L_{ij} > 3\sigma$. Eight of the nine industries are located in core regions with one in a periphery region. Industries categorised as (*DC*) have a concentration measure that changed from *relative* concentration $L_{ij} < 3\sigma$, to *absolute* concentration, $L_{ij} > 3\sigma$. One of these industries is located in an adjacent region. The industries categorised (*CD*) have an industry concentration measure L_{ij} that changed form an *absolute* concentration value $L_{ij} > 3\sigma$, to a *relative* concentration value, $L_{ij} < 3\sigma$. All three industries are located in core regions. Finally, the industries categorised as (*DD*), (*DLD*) and (*DMD*) remained *relatively* concentrated, $Lij < 3\sigma$. These industries are equally dispersed over core and adjacent regions.

[69] See Chapter 5, Appendix 5A, Table 5A.6

An Analysis of the Lij Concentration Measurement

The standardised concentration ratios are ranked by region and per CAP cluster in Table 5.13[70]. The regions with the highest absolute and relative concentration values are listed in column (1). The regions with a positive standard deviation are ranked for each industry in columns (2) – (4).

The outcome indicates nine industries increased their concentration in core regions, one in an adjacent region, and one in a periphery region. Three industries in core regions showed a marginal decline in absolute concentration. This leaves nine industries with relative concentrations spread over core and adjacent regions.

Increased Concentration (CC)

Nine industries have L_{ij} values that remained in the critical region post EU 1992. These industries have an absolute labour-land concentration coefficient. Five of the nine industries are located in the CAP cluster Pias Vasco, three in the CAP cluster of Madrid, and one in the CAP cluster of Cataluna. All industries are located in core regions with the exception of quarrying and mining of energy materials in the periphery region of Asturias. Three industries experienced a marginal decline (*CLC*), but maintained their absolute concentration status. The industries rubber and plastics, and fabricated metal products experienced a decline in the core region of Pias Vasco with an increased relative concentration in the remaining two core regions. Absolute concentration also declined in the textile industry in the core region of Cataluna with relative concentration increasing in its adjacent region of Communidad Valencia. The remaining six industries increased their absolute concentration levels in the core regions, reducing the relative concentrations in the other two core regions.

Dispersed More Concentrated (DC)

Five industries showed a relative concentration value of $L_{ij} < 3\sigma$ in 1989, but became absolutely concentrated $L_{ij} > 3\sigma$ in 1997. In the Energy sector, increased concentration occurred in three industries in the core region of Madrid. In the Other Manufacturing sector, increased concentration in the wearing apparel industry is evident in the core region of Madrid; the leather and leather products industry relocated from the core region Madrid to the adjacent region of Communidad Valencia. The industries classified as (*CC*) and (*DC*) combined, experienced an increased absolute concentration in eleven industries of which nine occurred in core regions.

TABLE 5.13

CHANGES IN INDUSTRY RELATIVE AND ABSOLUTE CONCENTRATION PER CAP CLUSTER 1997 & 1989

CAP Cluster Pias Vasco		Year	L_{ij}	*Region*	L_{ij}	*Region*	L_{ij}	*Region*	L_{ij}	*Region*
				(1)		(2)		(3)		(4)
Quarrying & mining of energy materials	CC*	1997	4.0	Asturias						
		1989	4.0	Asturias						
Basic metal products	CC*	1997	3.7	Pias Vasco	0.9	Asturias	0.4	Cantabria	0.1	Madrid
		1989	3.4	Pias Vasco	1.7	Asturias	0.2	Cantabria	0.2	Baleares
Machinery and equipment	CC*	1997	3.4	Pias Vasco	1.3	Madrid	0.8	Cataluna		
		1989	3.4	Pias Vasco	1.6	Madrid	0.5	Cataluna		
Fabricated metal products	CLC*	1997	3.4	Pias Vasco	1.5	Madrid	0.7	Cataluna		
		1989	3.6	Pias Vasco	1.1	Madrid	0.4	Cataluna		
Rubber and Plastics	CLC*	1997	3.1	Pias Vasco	1.6	Madrid	1.2	Cataluna	0.4	Com. Val.
		1989	3.4	Pias Vasco	1.3	Madrid	0.8	Cataluna	0.3	Com. Val.
Other transport	CD	1997	2.8	Pias Vasco	2.4	Madrid	0.5	Galicia		
		1989	3.2	Pias Vasco	1.9	Madrid	0.5	Galicia		
Quarrying and mining of non-energy	DMD	1997	1.8	Galicia	1.8	Cantabria	1.2	Madrid	1.1	Com. Val.
		1989	2.0	Galicia	1.5	Madrid	1.0	Cataluna	0.8	P. Vasco
CAP Cluster Madrid										
Office machinery and computers	CC*	1997	3.9	Madrid	0.6	Cataluna				
		1989	3.4	Madrid	1.5	Baleares	0.5	Cataluna	0.1	Com. Val.
Medical precision instruments	CC*	1997	3.6	Madrid	1.2	Pias Vasco	0.5	Cataluna		
		1989	3.2	Madrid	1.6	Cataluna	1.3	Pias Vasco		
Paper and paper products	CC*	1997	3.8	Madrid	0.7	Cataluna	0.5	Pias Vasco		
		1989	3.6	Madrid	1.0	Pias Vasco	0.6	Cataluna		
Chemicals and man made fibres	CD	1997	3.0	Madrid	2.2	Cataluna	0.7	Pias Vasco	0.1	Com. Val.
		1989	3.2	Madrid	1.7	Cataluna	1.0	Pias Vasco	0.1	Cantabria
Motors and trailers	CD	1997	2.6	Madrid	1.5	Cataluna	1.4	Pias Vasco	1.0	Navarra
		1989	3.3	Madrid	1.3	Cataluna	0.9	Pias Vasco	0.4	Navarra
Coke, refinery and nuclear energy	DC	1997	3.3	Madrid	1.3	Pias Vasco	0.7	Galicia	0.6	Asturias
		1989	2.8	Asturias	1.3	Pias Vasco	1.8	Murcia	0.4	Cataluna
Wearing apparel	DC*	1997	3.2	Madrid	1.9	Cataluna	0.5	Com. Val.	0.1	Galicia
		1989	2.6	Madrid	2.1	Com. Val.	0.9	Cataluna	0.7	La Rioja
Electrical machinery and apparatus	DLD	1997	2.9	Madrid	2.0	Pias Vasco	1.2	Cataluna		
		1989	2.6	Madrid	2.5	Pias Vasco	0.9	Cataluna		
Food, beverage and tobacco	DMD	1997	2.7	Madrid	1.4	Cataluna	0.8	Canarias	0.7	P. Vasco
		1989	2.8	Madrid	1.0	Cataluna	0.8	Pias Vasco	0.5	Com. Val.
Manufacture of jewellery and musical	DLD	1997	2.7	Madrid	1.7	Com. Val.	1.2	Pias Vasco	0.7	Cataluna
		1989	2.2	Madrid	1.9	Com. Val.	1.6	Pias Vasco	0.7	Baleares
Electricity, gas and steam	DC	1997	3.4	Madrid	1.2	Pias Vasco	0.8	Baleares	0.2	Cataluna
		1989	3.0	Madrid	1.3	Pias Vasco	0.7	Cataluna	0.3	Canarias
Purification and distribution of water	DC	1997	3.8	Madrid	0.4	La Rioja	0.3	Baleares	0.2	Cataluna
		1989	2.3	Madrid	1.5	Pias Vasco	1.2	Canarias	0.9	Asturias
CAP Cluster Cataluna										
Textiles	CLC*	1997	3.4	Cataluna	1.8	Com. Val.	0.1	Madrid		
		1989	3.7	Cataluna	1.2	Com. Val.	0.2	La Rioja		
Leather and leather products	DC*	1997	3.5	Com. Val.	1.0	Baleares	0.9	La Rioja	0.1	Madrid
		1989	2.6	Madrid	1.8	Com. Val.	1.7	Cataluna	0.2	Murcia
Wood products	DLD	1997	2.3	Com. Val.	1.4	Pias Vasco	1.2	Madrid	0.9	Cataluna
		1989	2.1	Com. Val.	1.8	Madrid	1.8	Pias Vasco	0.4	Cataluna
Non-metallic minerals	DLD*	1997	2.8	Com. Val.	2.0	Madrid	0.9	Pias Vasco	0.6	Cataluna
		1989	2.5	Com. Val.	1.9	Madrid	1.5	Pias Vasco	0.6	Cataluna

Source: Author's own research. * = Regions with the highest manufacturing location-Gini's

Concentrated More Dispersed (CD)

The chemicals and man made fibre industry was absolutely concentrated in the core region of Madrid in 1989 and showed a relative concentration in 1997 in the core regions of Madrid with an increase in Cataluna. The motor and trailer industry, with an absolute concentration in Madrid in 1989, saw an absolute concentration decline in 1997 to one of increased relative concentration in the core

[70] The standardised normal labour-land concentration ratios are categorised per industry sector in Table 5A.6,

agglomerates of Cataluna and Pias Vasco. Finally, a similar change in absolute concentration occurred in the other transport sector in the core region of Pias Vasco with relative concentrations relocating to the core region of Madrid and the adjacent region of Galicia.

Dispersed Less/More Dispersed (DD)

The industries in this category all have a relative labour-land concentration coefficient. This group is comprised of six industries of which two industries experienced more dispersion (*DMD*), and four industries less dispersion (*DLD*). In Galicia, the industry quarrying and mining of non-energy materials deceased its relative concentration level, but increased its relative concentration in the adjacent region of Cantabria in the same CAP cluster. The food, beverage and tobacco industry in Madrid experienced a marginal relative concentration decline in its own core region, and an increased relative concentration share in the core regions of Cataluna and the island-periphery region of Canarias.

The four industries that became less dispersed (*DLD*) maintained the initial relative concentrations in the same regions, but resulted in a change in relative concentration in non-adjacent core regions. In the industry electrical machinery and apparatus the relative concentration ratio increased in the core regions of Madrid and Cataluna, but declined in Pias Vasco. The relative concentration ratio of the manufacture of jewellery and musical instruments increased in the core region of Madrid and declined in Pias Vasco and Communidad Valencia. The relative concentration of the wood products industry increased in the adjacent region Communidad Valencia and its core region Cataluna, and became relatively less concentrated in Pias Vasco and Madrid. Finally, the non-metallic industry increased its relative concentration in the adjacent region of Communidad Valencia and Madrid at the expense of the core region Pias Vasco.

In general, only two industries in the group (*DC*) relocated to different regions as a consequence of their increased absolute concentration between 1989 and 1997. In the Energy sector the industry coke, refinery and nuclear relocated from the periphery region Asturias to the core region of Madrid. In the Other Manufacturing sector, the industry leather and leather products relocated from the core region of Madrid to the adjacent region of Communidad Valencia in the CAP cluster Cataluna. Industry concentration in all other categories (*CC*), (*CD*) and (*DD*) – twenty-one industries – remained in the regions of their respective initial concentration. Of the total twenty-three industries, seventeen are located in core agglomerates, one in a periphery region Asturias, one in the adjacent region of Galicia, and three in the adjacent region Communidad Valencia.

What is significant about the new absolute and relative labour-land concentration measurement? First, it relates employment per industry to a square kilometre thereby compensating for a region's geographic size. Since the new economic geography focuses on industry location, then its concentration

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must be measured geocentrically. Second, it relates consistently to the centrality theory within the framework of the CAP model. The majority of industries are absolutely or relatively concentrated in core agglomerates. The measurement unequivocally facilitates the necessary proof for regional diversified agglomeration (Krugman and Venables1996) and the home market effect (Krugman, 1991b; Davis and Weinstein, 1999). Third, it support the seamless concentric circle theory by identifying manufacturing dispersion (relative concentration) to adjacent and periphery regions (Von Thünen, 1823), thereby revealing the strength of the competition effect (Krugman, 1991b; Venables, 1994; Baldwin *et.al.*, 2002), and regions with a comparative advantage (Forslid and Wooton, 1999).

5.7.5 An Empirical Examination of Industry Characteristics

Midelfart *et.al.*, (2000) have identified industry characteristics in their study of EU industry location at the national level. These industry characteristics are applied to the industries in the regions of Spain and are listed in Table 5.14. The industry characteristics are categorised as high (H), medium (M) and low (L).

TABLE 5.14
INDUSTRY CHARACTERISTICS

1	*Economies of scale*	*IRS*	*= Measures of minimum efficient scale (MES)*
2	*Technology level*	TECH	= High, Medium, Low (OECD classification)
3	*Intra-industry linkages*	INTRA	= Use of intermediates from own sector as share of value of production
4	*Inter-industry linkages*	INTER	= Use of intermediates from other sectors as share of value of production
5	*Capital intensity*	K/L	= Capital stock per employee
6	*Skill intensity*	S/L	= Share of non-manual workers in the workforce
7	*Industry growth*	Δ	= Growth in value of production between 1970 and 1994
8	*Final demand bias*	F	= Percentage of sales to domestic consumers and exports
9	*Agricultural input intensity*	A	= Use of primary inputs as share of value of production

Source: Midelfart *et. al.*, (2000), Box 2.2, p.13

In Table 5.15, the industries and their characteristics are presented in their CAP clusters and region types in which their absolute and relative concentration occurs. We are interested in answering the question; "Is there a difference in industry characteristics between the CAP clusters that determines their location?"

The (CC) Industries

The eight (*CC*) industries are located in two core agglomerates and have increased their concentration at the expense of the adjacent, periphery and core regions.[71] The (*CC*) industries are located in the core agglomerates of Pias Vasco and Madrid. The difference in industry characteristics between these two agglomerates is that industries located in Madrid have a higher technology requirement, a higher need for intra and inter-industry inputs, and higher skill requirements. Industries in Madrid use a larger share of agricultural inputs, and produce relatively more for home consumption. Industries in Pias

[71] See Table 5.14

Vasco are more capital intensive, use low levels of agricultural inputs, and have a low demand bias indicating strong home market effects (Davis and Weinstein, 1999). The industry quarrying and mining of energy materials is completely concentrated in the periphery region of Asturias suggesting regional natural advantage (Ellison and Glaeser, 1999). The CAP cluster Pias Vasco is in close geographic proximity to the core regions of Portugal in the west and borders on France to the north. The regions in this cluster could possibly be developing an export industry.

TABLE 5.15
INDUSTRY CHARACTERISTICS

Industries	*CAP Cluster (R)*	*IRS*	*TECH*	*INTRA*	*INTER*	*K/L*	*S/L*	*Λ*	*F*	*A*
Quarrying & Mining Energy Materials (CC)	Pias Vasco (P)	H	L	L	H	H	H	M	H	L
Basic Metal products (CC)	Pias Vasco (C)	M	L	M	M	M	L	H	L	L
Machinery and Equipment (CC)	Pias Vasco (C)	M	M	M	M	M	H	M	L	M
Fabricated Metal products (CLC)	Pias Vasco (C)	M	L	M	M	M	L	H	L	L
Rubber & Plastics (CLC)	Pias Vasco (C)	L	M	L	H	L	M	L/M	M	H
Other Transport (CD)	Pias Vasco (C)	H	M	L	H	M	M	L	L	L
Quarrying & Mining Non-Energy (DMD)	Pias Vasco (A)	H	M	H	L	H	M	M	M	L
Office Machinery & Computers (CC)	Madrid (C)	M	H	M	H	L	H	H	L	L
Medical Precision Instruments (CC)	Madrid (C)	M	H	L	M	L	H	H	M	M
Paper & Paper Products (CC)	Madrid (C)	M	L	H	L	H	M	M	L	M
Chemicals & Man Made Fires (CD)	Madrid (C)	H	M	H	L	H	H	M	M	M
Motors & Trailers (CD)	Madrid (C)	H	M	H	M	M	L	L	H	L
Coke, Refinery & Nuclear (DC)	Madrid (C)	H	L	L	M	H	H	H	H	L
Wearing Apparel (DC)	Madrid (C)	L	L	H	L	M	L	L	H	H
Electrical Machinery & Apparatus (DLD)	Madrid (C)	M	H	M	M	L	M	H	M	M
Food, Beverages & Tobacco (DMD)	Madrid (C)	L	L	M	H	H	H/M	M/H	H	H
Manufacture of Jewellery & Musical † (DLD)	Madrid (C)									
Electricity, Gas & Steam † (DC)	Madrid (C)									
Purification & Distribution of Water † (DC)	Madrid (C)									
Textiles (CLC)	Cataluna (C)	L	L	H	L	M	L	L	H	H
Leather & Leather Products (DC)	Cataluna (A)	L	L	H	L	M	L	L	H	H
Wood Products (DLD)	Cataluna (A)	L	L	M	M	L	L	M	M	H
Non-Metallic Minerals (DLD)	Cataluna (A)	M	L	M	M	L	M	M	L	M

Source: Industry characteristics taken from Table 3.4 in Midelfart *et. al.*, (2000). † = no industry characteristics available

The (CLC) Industries

The three (*CLC*) industries located in core agglomerates have an absolute concentration that has declined but remains absolute. There are no (*CLC*) industries in Madrid. Two of these industries are located in the core region of Pias Vasco, and one in the core region of Cataluna. In Pias Vasco the industries fabricated metal products, and rubber and plastics have the opposite characteristics except for inter-industry linkages, industry growth, and use of agricultural inputs. The fabricated metal products industry, like other (*CC*) industries in Pias Vasco has a medium level of internal returns to scale, medium intra and inter-industry linkages, and requires medium capital intensity. It is has a low final demand bias indicating it is an export industry.

The rubber and plastics industry is a supplier industry with low level of internal returns to scale, a high level of inter-industry linkages, a medium skilled labour requirement, and a medium final demand bias. The industry's relative concentration levels have increased in the core agglomerates of Madrid and Cataluna. The industry's medium final demand bias, medium levels of skilled labour needs, and high levels of inter-industry needs, suggests that industry relocation is fuelled by the need for domestic expenditure, skilled labour and technology availability, and inter-industry linkages available in the larger two core agglomerates (Krugman and Venables, 1996).

The third (*CLC*) industry is the textile industry with a declining, but stable, absolute concentration in the core agglomerate Cataluna. The industry has experienced an increase in relative concentration in its adjacent region of Communidad Valencia. The industry is characterised by low internal returns to scale, high intra-industry linkages, medium capital intensity, a high use of agricultural inputs, and a high final demand bias. The increased relative concentration in the adjacent region suggests a possible need for an input-output structure with similar industries in the core; this, combined with low internal returns to scale, suggests relatively high product transport intensity (Venables and Limao, 2002). Also, the industry produces primarily for domestic consumption and therefore needs to locate in the largest domestic home market, which is the core agglomerate of Cataluna.

The (DC) Industries

The (*DC*) industries are those that have changed from relative to absolute concentration. Two of the (*DC*) industries are located in core agglomerate Madrid and one in the core agglomerate Cataluna. In Madrid, the coke, refinery and nuclear energy industry has become absolutely concentrated out of need for high internal returns to scale, medium inter-industry linkages, high capital intensity requirements, the need for skilled labour, and high final demand bias. It has low levels of agricultural inputs. The industry has relocated from the periphery region Asturias that is left with a small relative concentration.

The wearing apparel industry has found absolute concentration in the core region of Madrid. The industry has low levels of internal returns to scale, is highly dependent on intra-industry linkages, has a high final demand bias, and possibly a high demand elasticity. The industry is highly dependent on agricultural inputs that bear transportation costs, making the industry transport intensive. It therefore needs to be located in its largest domestic home markets. The industry also shows dispersion to the core agglomerate of Cataluna, which has the highest relative concentration coefficient. The industry has relocated primarily form the adjacent region of Communidad Valencia.

The leather and leather products industry has an absolute concentration in the adjacent region of Communidad Valencia. The industry has relocated from the core agglomerates of Madrid and Cataluna. This industry is also characterised by low internal returns to scale, high intra-industry linkages, medium capital intensity, a high use of agricultural inputs, and produces primarily for the domestic market. The industry is highly dependent on agricultural inputs, making its commodities relatively transport intensive.

The (CD) Industries

There are three (*CD*) industries that have lost their absolute concentration, have become more dispersed, and now have relative concentration. The first (*CD*) industry is the other transport industry located in the core agglomerate of Pias Vasco. The industry has dispersed primarily to the core agglomerate Madrid. The other transport industry in Pias Vasco is characterised by high internal returns to scale, low intra-industry linkages, but high inter-industry linkages. It requires medium levels of technology, capital intensity, and skilled labour. It requires low levels of agricultural inputs, shows low industry growth, and has a low final demand bias.

The other transport industry is a supplier industry. Relocation to Madrid could be driven by its need for high internal economies of scale, and high inter-industry linkages. Since this is an export industry, these relocation developments suggest the need to minimise the high transport intensity costs of importing intermediate products from the core region of Madrid. By relocating to Madrid it reaps pecuniary agglomeration benefits which allows it to remain competitive in foreign markets. The developments in this industry embody the forces of the new economic geography theory of home market effect, transport intensity of commodities, and satisfying idiosyncratic demand (Krugman, 1991b; Krugman and Venables, 1996; Davis and Weinstein, 1999; Venables and Limao, 2002).

The remaining two industries in the (*CD*) group are located in the core agglomerate of Madrid. The industries chemicals and man made fibres, and motors and trailers have both experienced relocation to the core agglomerate Cataluna, whose relative concentration coefficients have increased for both industries. The industry branche motors and trailers has become relatively more dispersed than chemical since it has also relocated to the core agglomerate of Pias Vasco, whose relative concentration coefficient is approximately the same as that of Cataluna. The industries are similar in their need for high internal returns to scale, medium levels of technology, and high intra-industry linkages.

The chemical industry is a supplier industry and requires low inter-industry linkage, but high capital intensity and high levels of skilled labour. The industry has experienced medium growth, and has a medium final demand bias. Since the chemical industry is producing for domestic and foreign consumption it will locate to large markets such as Cataluna with high initial high industry shares, to reap the pecuniary agglomerate advantages from high intra-industry linkages and high internal economies of scale (Forslid *et. al.,* 1999). The industry can supply the southern and northern European market from these two core agglomerates (Davis and Weinstein, 1999).

The motors and trailers industry has characteristics similar to the chemical industry. It, however, has a high final demand bias suggesting production primarily for the domestic market. To minimise the transport intensity costs of its high dependence on intra-industry inputs, and to realise high levels of internal returns to scale, this industry is dispersing and relocating to core agglomerates with initial high industry shares thereby contributing to the changing composition of industry structures in core agglomerates (Krugman and Venable, 1996).

The (DD) Industries

The categories (*DMD*) and (*DLD*) contain industries that are relatively concentrated and experience an increase or decrease in this position. In the CAP cluster of Pias Vasco the industry quarrying and mining of non-energy materials has a decline in relative concentration (*DMD*) in the *ex post* adjacent region Galicia, and relocated to the adjacent region of Cantabria with an equal relative concentration. The industry is characterised by high internal returns to scale, *intra*-industry linkages, and capital intensity. Both Galicia and Cantabria are adjacent regions. It has low *inter*-industry linkage, and medium levels of technology, skilled labour, and a medium final demand bias, producing for domestic consumption and export. The industry has medium growth levels.

In the CAP cluster of Cataluna, the industries wood products and non-metallic minerals have relative concentration levels and are both becoming less dispersed (*DLD*). Both industries are located in the adjacent region of Communidad Valencia. The industry characteristics are similar except for internal returns to scale, skilled labour requirements, final demand bias, and use of agricultural inputs. The non-metallic industry has a low final demand bias and a high need for agricultural inputs. It is a transport intensive industry competing in foreign export markets. The wood products industry has a high use of agricultural inputs and a medium demand bias requiring location close to the home market.

Conclusion Relative and Absolute Concentration Analysis

It is evident that the industrial structure of core regions consists of a mix of industries that show both absolute and relative concentration, For example, the core agglomerate of Pias Vasco has five industries with absolute concentration, and one with relative concentration. Madrid has seven industries that are absolutely concentrated and five industries that are relatively concentrated. The core agglomerate of Cataluna has one absolutely concentrated industry. Adjacent and periphery regions within the CAP clusters also show absolute and relative concentration in five industries.

In general, increased concentration (*CC*) in one core region is accompanied by declining relative concentration in the remaining core regions. Industries in core regions with a marginal decline in absolute concentration (*CLC*) increase their relative concentration in other core regions. Dispersed industries with a relative concentration that have become absolutely concentrated (*DC*) have relocated primarily to the core agglomerate of Madrid, with the exception of one industry that relocated to an adjacent region. Industries that were absolutely concentrated, but became more dispersed (*CD*) increased their industry relative concentration ratio in another core agglomerate or adjacent region. Dispersed industries that became less dispersed (*DLD*) increased their relative concentration at the expense of other core regions. The two (*DMD*) industries are located in two separate CAP clusters. In the CAP cluster Pias Vasco relative concentration ratios became identical in two adjacent regions at the expense of core regions. In the CAP cluster Madrid, dispersion occurred from one core to another core region.

The industry analysis in Section 5.4 revealed that new firms in similar industrial sectors locate in both core and adjacent regions of all three CAP clusters. The analysis also revealed that new firms in different industrial sectors cluster in common regions, irrespective of region type, i.e. core and adjacent. The industry characteristics analysis reveals fifteen industries, located in core and adjacent regions, that require medium to high *intra*-industry linkages, and thirteen industries, located in similar region types, requiring medium to high *inter*-industry linkages. This evidence supports the concentric circle theory that input-output structures – forward and backward linkages – exist between core agglomerates and their adjacent regions (Paelinck and Nijkamp, 1975; Krugman and Venables, 1996; Midelfart *et.al.*,2000). The CAP clusters in Spain have developed economic districts (Lösch, 1954; Krugman, 1991a).

Furthermore, the outcome of the industry index analysis revealed greater similarity in production structures between the core agglomerates and their adjacent regions. The existence of a multi-agglomerate production structure has been revealed through the analysis of changes in relative and absolute industry concentration. This evidence supports the theory of diversified agglomeration in the theoretical literature (Krugman and Venables, 1990, 1995, and 1996; Venables, 1994; Ludema and Wooton, 1997; Forslid and Wooton, 1999; Venables and Limao, 2002). Trade liberalisation has not weakened nor destabilised the original core agglomerates. It has, however, changed their industrial composition (Krugman and Venables, 1996).

5.7.6 CAP Cluster Characteristics

It appears that industry and commodity characteristics are correlated with CAP cluster characteristics. The concentration categories (*CC*), (*CLC*) and (*DC*) comprise twelve industries distributed over the three CAP clusters. Of these, five are located in the cluster Pias Vasco, five in the cluster of Madrid, and two in the cluster Cataluna. On average the industries in Pias Vasco have a low demand elasticity indicating home market economic geography effects since they produce primarily for the export market (Davis and Weinstein, 1999).

The CAP cluster Pias Vasco appears to have a number of characteristics[72] that attract the export industry. First, it has a favourable geographic locational advantage for industries exporting to Portugal, France, and the EU geographic core. Second, it has a modern road and rail infrastructure providing transport routes to Portugal and France. Third, the city of La Corunna in the adjacent region of Galicia has an Atlantic Ocean seaport and two of the six airfields in the CAP cluster Pias Vasco. Since, industries are increasing their concentration in the core agglomerate, we can assume that Pias Vasco has an abundance of skilled labour and educational programs to ensure a continued supply of human capital.

The CAP cluster Madrid contains five industries with absolute concentration. On average these industries have a medium to high need for internal returns to scale, intra-industry linkages, and skilled

[72] The source for this information is Eurostat (1993), *Portrait of the Regions,* Volumes. 1- 4, Luxembourg.

labour. They are characterised by a medium to high final demand bias indicating the need for high demand in home markets. The industries are also characterised by medium to high needs for agricultural inputs. The (*CD*) and (*DLD*) in Madrid are characterised by a medium to high final demand bias and need for agricultural inputs. The core agglomerate of Madrid has the highest number of industries with absolute and relative concentration.

The CAP cluster Madrid is characterised by its favourable central geographic location equidistant from the core agglomerates Pias Vasco and Cataluna, respectively 624km and 617km. It has a modern infrastructure. The region Madrid consists of 15 urban areas of which six have a total population greater than 100,000 people. It has an urban population of 89.3%, compared to 69.6% in Pias Vasco and 68.9% in Cataluna. The region has a number of universities and vocational institutions providing technological know-how and a skilled labour force. Two adjacent regions Castilla La Mancha and Castilla Leon whose land use is respectively 63% and 59% agricultural surround the agglomerate Madrid.[73] This geographic characteristic makes manufacturing location in Madrid interesting for industries whose commodities are characterised by transport intensive agricultural inputs, and yet wish to compete in foreign export markets, such as the industry paper and paper products.

The common characteristic of the (*DC*) industries is the high final demand bias for their commodities and high needs for agricultural inputs, causing their relocation to the high expenditure agglomerates of Madrid and Cataluna. The same is true for the one of the (*DLD*) industries in this CAP cluster. The industry (*DLD*) non-metallic minerals is an export oriented industry.

The CAP cluster Cataluna is characterised by 35 urban areas of which eight have a population exceeding 100,00 people with a population density in Barcelona 615 people per square kilometre[74]. Its adjacent region of Communidad Valencia also has 35 urban areas of which four have a population greater than 100,000 people. The urban population density of Communidad Valencia is 56.6%. Average land use in Cataluna and Communidad Valencia is about 43% agriculture and 41% wooded. The CAP cluster Cataluna has three Mediterranean harbours, one in Cataluna in the city Barcelona, and two in Communidad Valencia in the city Alicante. It has an equal number of airports, one in Barcelona, and two in Alicante. The CAP cluster is characterised by a modern road and rail infrastructure along the northern Mediterranean coast for easy market access to southwestern France, northern Italy, and the EU geographic core. The cluster has Universities and vocational institutions providing technological know-how and a skilled labour market.

5.8 CONCLUSIONS

This chapter made an initial analysis of the endogenous economic mechanisms that comprise the 'black box' of the new economic geography model within the CAP framework. The initial outcomes

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[73] *Ibid., Op.Cit.*,(1993)
[74] *Ibid, Op.Cit.*, (1993)

suggest the CAP model to be a functional vehicle for analysing inter-regional and inter-sectoral firm and labour movements in a seamless geographic world.

The outcomes prove the premise of the concentric circle theory that industry location radiates outward in multi-directions from a central location. The CAP model, through the concept of CAP clusters, facilitates the industry index analysis in exposing the convergence or divergence of industry structures in the first concentric circle around the core. When applied to the second concentric circle, the model reveals that even industries in these regions tend to develop industry structures similar to their nearest core region. In the case of the CAP cluster Pias Vasco the distance of production location from the core becomes less relevant if the commodity has a low final demand bias.

The concentric circle theory approach to the analysis of industry location provides the distinct advantage of identifying one or more core regions within a country that act as an economic development axes, attracting and dispersing economic activity to its surrounding regions. The CAP model allows for the measurement of this spatial activity. The outcome has revealed a major theoretical premise by Krugman and Venables (1996) that supplier and final goods producers seek to cluster for pecuniary agglomerate advantage. The regional CAP model identified this behaviour by examining the sectoral distribution of industries within the CAP clusters. It found five distinct instances where supplier and final goods producers clustered in a common region or the combination of core and adjacent regions. Contrary to the results reported by Midelfart *et.al.*,(2000), a region's initial 'low' or 'high' share in an industry is important for industry clustering. Core regions with high initial shares attract new firms into the industry dispersing other firms in need of forward and/or backward linkages to the adjacent regions.

The new labour-land concentration ratio verifies the initial signals from the industry index analysis that Spain is characterised by a multi-agglomerate production structure. Trade liberalisation has left original agglomerate production structures in place, but has changed the composition of industrial structures. A comparison of industry concentration measurements are listed in Table A.6.7. The characteristics of the measurements are such that only the new labour-land concentration ratio meets the two requirements of; one, measuring industry concentration per region, and two, providing a clear cut-off point between absolute and relative concentration. The remaining three measurements do not satisfy one of the two criteria. The location-Gini, LG_{ij} measures industry concentration per region, but cannot distinguish between relative and absolute concentration. The Amiti (1997) and Forslid (1999) relative and absolute measurements are country and not region specific. Finally, the measurements are not consistent in their concentration values.

This study does not make the claim that the relative concentration ratio measures Heckscher-Ohlin comparative advantage and specialisation in production, or that the absolute concentration ratio measures Krugman's (1991b) economic geography and economies of scale. However, first indications do suggest that on average industries experiencing absolute concentration (*CC*), in the core agglomerates are characterised by low to medium final demand bias indicating strong economic geography home market effects, as found by Davis and Weinstein (1999). Industries with relative concentration ratios are located in core and adjacent regions and are characterised as industries in the dispersed – more/less – dispersed categories, (*DLD*) and (*DMD*). On average these industries show a medium to high final demand bias indicating the need for proximity to high domestic expenditures. These industries show greater dispersion across the CAP clusters suggesting regional specialisation in production for domestic consumption. Multiple production locations would lead one to deduce that these industries have commodities with high demand elasticities and high transport intensities dependent on *intra* and *inter*-industry inputs.

Finally, the CAP model proves the multi-agglomerate production structure in Spain. It is not unreasonable to conclude that this polycentric production structure is the result of the geographic location and characteristics of the three agglomerates. The CAP cluster Pias Vasco in the northwest has a favourable geographic export location to France, Portugal, and the rest of the world via the Atlantic Ocean harbours. The CAP cluster Madrid is centrally located, equidistant from Pias Vasco and Cataluna. A high percentage of its land use, and that of its adjacent regions, is agricultural production, whose output serves as inputs (medium and high) for six of the twelve industries concentrated in the agglomerate. The CAP cluster Cataluna is the largest home market in Spain. Its prime characteristic is its share of domestic expenditure for firms with high final demand bias and transport intensive commodities. Its industry structure is favourable to all industries since it provides high levels of forward and backward linkages, *ergo*, pecuniary agglomerate advantages, which provides its comparative advantage. Like Pias Vasco, the cluster Cataluna has a rail, road, air, and harbour infrastructure to the outside world.

TABLE 5A.1
MANUFACTURING INDUSTRY DATA

NR.	*BR.*	*INDUSTRY NAMES*	*YEARS*	
		INDUSTRIAL SECTORS		
		ENERGY		
1	E40	Electricity, gas, steam, and hot water supply	1997	1989
2	E41	Collection, purification, and distribution of water	1997	1989
3	CA	Mining and quarrying of energy producing materials	1997	1989
4	DF	Manufacture of coke, refined petroleum products and nuclear fuel	1997	1989
		EXTRACTION AND PROCESSING		
5	CB	Mining and quarrying except energy producing materials	1997	1989
6	DG	Manufacture of chemicals, chemical products, and man made fibres	1997	1989
7	DH	Manufacture of rubber and plastics	1997	1989
8	DI	Manufacture of other non metallic mineral products	1997	1989
		ENGINEERING		
9	DJ27	Manufacture of basic metals	1997	1989
10	DJ28	Manufacture of fabricated metal products	1997	1989
11	DK	Manufacture of machinery and equipment	1997	1989
12	DL30	Manufacture of office machinery and computers	1997	1989
13	DL31	Manufacture of electrical machinery and apparatus	1997	1989
14	DL33	Manufacture of medical, precision, optical instruments, watches and clocks	1997	1989
15	DM34	Manufacture of motor vehicles, trailers, and semi-trailers	1997	1989
16	DM35	Manufacture of other transport equipment	1997	1989
		OTHER MANUFACTURING		
17	DA	Manufacture of food products, beverages, and tobacco	1997	1989
18	DB17	Manufacture of textiles	1997	1989
19	DB18	Manufacture of wearing apparel	1997	1989
20	DC	Manufacture of leather and leather products	1997	1989
21	DD	Manufacture of wood products	1997	1989
22	DE	Manufacture of paper and paper products	1997	1989
23	DN	Manufacturing: furniture, jewellery, musical instruments.	1997	1989

TABLE 5A.2

CHANGES IN INITIAL 'HIGH/LOW' LEVELS OF INDUSTRY CONCENTRATION

Absolute Concentration (Numbers)				es7 94	es11 77	es12 78	es13 79	es21 80	es22 81	es23 82	es41 85	es3 84	es42 86	es43 87	es61 91	es24 83	es51 88	es52 89	es62 92	es53 90
				Canarias	Galicia	Asturias	Cantabria	Pias Vasco	Navarra	Rioja	C-Leon	Madrid	C- Mncha	Extremadura	Andalucia	Aragon	Cataluna	Com. Val.	Murcia	Baleares
				IP1:2	A1:2	P1:1	A1:1	C4:1	A2:1	A2:1	A2:1	C	A3:5	P3:2	P1:3	A3:3	C4:1	A1:2	P2:1	IP1:2
ENERGY																				
(1)	Electr.,Gas,Steam	1989	E40	1.0														6.5	1.2	0.6
		1997		4.4														81.1	1.9	3.1
		Change		3.4														74.6	0.7	2.5
(2)	Purif,distr. Water	1989	E41	1.1								0.6		2.1	5.3		7.4	4.3	0.3	0.6
		1997		12.1								8.0		3.6	15.7		16.6	18.3	3.9	6.8
		Change		11.0								7.4		1.5	10.4		9.2	14.0	3.6	6.2
(3)	Q & M Energy Materials	1989	CA		0.9						51.6	0.0	1.8		1.4					
		1997			1.3						57.8	4.5	3.9		3.2					
		Change			0.4						6.2	4.5	2.1		1.8					
(4)	Coke, Refinery, Nuclear	1989	DF		5.6							0.0			11.1		11.1			
		1997			24.0							16.0			16.0		16.0			
		Change			18.4							16.0			4.9		4.9			
EXTRACTION AND PROCESSING OF NON-ENERGY-PRODUCINH MATERIALS																				
(5)	Q & M Non-Energy Material	1989	CB		8.1	1.5		1.8	0.9		7.4	3.5	6.2		3.0	3.6	6.9	3.3	0.0	
		1997			17.5	2.7		2.9	1.1		9.0	5.0	6.5		16.5	4.1	10.7	11.9	3.2	
		Change			9.4	1.2		1.1	0.2		1.6	1.5	0.3		13.5	0.5	3.8	8.6	3.2	
(6)	Chmicls & Fibres	1989	DG									11.8		0.6	8.0		31.7	14.2		
		1997										14.2		0.7	8.2		35.7	15.4		
		Change										2.4		0.1	0.2		4.0	1.2		
(7)	Rubber & Plastics	1989	DH	1.0	2.4							11.0	2.6		5.5		31.0			
		1997		1.5	4.2							13.0	2.7		5.7		34.5			
		Change		0.5	1.8							2.0	0.1		0.2		3.5			
(8)	Non-Metalic Minrls	1989	DI	1.8		1.7						4.9			17.4		15.0	17.9		
		1997		2.0		1.8						5.8			18.4		16.2	19.3		
		Change		0.2		0.1						0.9			1.0		1.2	1.4		
METAL MANUFACTURE; MECHANICAL, ELECTRICAL, AND INSTRUMENT ENGINEERING																				
(9)	Basic Metal Prdcts	1989	DJ27			2.6				0.6		10.2	1.5		4.7	3.2	21.1			0.0
		1997				2.7				0.8		12.7	2.1		5.5	3.3	30.1			0.3
		Change				0.1				0.2		2.5	0.6		0.8	0.1	9.0			0.3
(10)	Fabrctd Metal Prdcts	1989	DJ28	1.5		1.5		8.6				9.2					20.9	10.8		
		1997		2.1		1.9		10.7				12.5					26.5	11.3		
		Change		0.6		0.4		2.1				3.3					5.6	0.5		
(11)	Machnry Equipmnt	1989	DK	0.3							3.7	7.8			5.8		28.3		3.4	0.6
		1997		0.5							3.9	9.2			7.3		34.0		4.3	0.7
		Change		0.2							0.2	1.4			1.5		5.7		0.9	0.1
(12)	Office Machnry, Comptrs	1989	DL30		2.0	0.0			0.0		3.9		2.0	0.0	2.0			3.9		
		1997			2.3	1.1			0.6		5.1		4.0	1.1	8.5			11.3		
		Change			0.3	1.1			0.6		1.2		2.0	1.1	6.5			7.4		

TABLE 5A.2

CHANGES IN INITIAL 'HIGH/LOW' LEVELS OF INDUSTRY CONCENTRATION

(13)	Electrcl Machnry, Apparts	1989	DL31	1.4		1.7					2.0			4.6		9.6	1.8	0.6
		1997		1.7		1.9					2.6			7.4		13.4	2.3	1.1
		Change		0.3		0.2					0.6			2.8		3.8	0.5	0.5
(14)	Medcal Precision Intrmts	1989	DL33	1.0				0.5		19.3	1.2		6.2		24.7	13.1		
		1997		1.7				1.1		24.9	1.2		7.4		25.7	14.1		
		Change		0.7				0.6		5.6	0.0		1.2		1.0	1.0		
(15)	Motors & Trailers	1989	DM34			1.0			0.9		3.2		7.1	5.8	23.5	8.1	2.5	0.0
		1997				1.3			1.3		3.8		7.4	7.7	30.5	8.7	2.9	0.5
		Change				0.3			0.4		0.6		0.3	1.9	7.0	0.6	0.4	0.5
(16)	Other Transprt.	1989	DM35	5.9				0.2	0.1	1.8			14.3					4.7
		1997		8.0				0.5	0.3	3.6			19.4					12.1
		Change		2.1				0.3	0.2	1.8			5.1					7.4
OTHER MANUFACTURING INDUSTRIES																		
(17)	Food, Bevrge & Tobacco	1989	DA	2.1	6.7	2.0	2.1		1.2	4.0			16.6		14.2	12.7	3.5	1.9
		1997		2.5	7.8	2.6	2.9		1.5	5.6			17.4		15.6	13.2	5.0	2.1
		Change		0.4	1.1	0.6	0.8		0.3	1.6			0.8		1.4	0.5	1.5	0.2
(18)	Textiles	1989	DB17	0.1	1.8	0.1	0.9			1.6	2.2	0.2	2.5	1.2		25.0	1.1	0.2
		1997		0.8	2.3	0.3	1.1			4.8	2.2	0.3	6.3	1.2		25.1	2.0	1.0
		Change		0.7	0.5	0.2	0.2			3.2	0.0	0.1	3.8	0.0		0.1	0.9	0.8
(19)	Wearng Apparel	1989	DB18		5.7					7.1	9.6	1.4			15.6			
		1997			6.6					13.4	9.9	1.4			38.0			
		Change			0.9					6.3	0.3	0.0			22.4			
(20)	Leather & Leather Prdcts	1989	DC						1.6		3.5					23.2	2.6	3.5
		1997							4.0		6.0					60.0	3.6	4.4
		Change							2.4		2.5					36.8	1.0	0.9
(21)	Wood Prdcts	1989	DD	3.3		2.0			0.9			1.9		2.2	18.2	15.2	3.1	2.8
		1997		3.8		2.4			1.0			2.1		2.8	20.8	17.3	3.6	3.2
		Change		0.5		0.4			0.1			0.2		0.6	2.6	2.1	0.5	0.4
(23)	Paper & Paper Prdcts	1989	DE		3.3					19.2					23.9			
		1997			3.5					27.1					29.2			
		Change			0.2					7.9					5.3			
(23)	Mncftrg, Jewlery, Musical	1989	DN							6.4			11.7		17.6	14.9		
		1997								12.6			13.5		22.4	19.6		
		Change								6.2			1.8		4.8	4.7		

Source: Authors own research. Data from Eurostat.

TABLE 5A.3

CHANGES IN REGIONAL MANUFACTURING EMPLOYMENT 1989 - 1997

Change in the regions number of manufacturing employees		es7 94	es11 77	es12 78	es13 79	es21 80	es22 81	es23 82	es41 85	es3 84	es42 86	es43 87	es61 91	es24 83	es51 88	es52 89	es62 92	es53 90
		Canaria	Galicia	Asturias	Canta.	P. Vasco	Navarra	Rioja	C-Leon	Madrid	C- Mncha	Extrem.	Andaluci	Aragon	Catal.	Com. Val.	Murcia	Baleares
Spain		IP1:2	A1:2	P1:1	A1:1	C4:1	A2:1	A2:1	A2:1	C	A3:5	P3:2	P1:3	A3:3	C4:1	A1:2	P2:1	IP1:2
Energy																		
(1) Electr.,Gas,Steam	E40	-464	-1494	-1563	-84	-77	-118	119	-1034	1300	-964	-562	-961	-1926	-3725	-597	-48	-171
(2) Purif,distr. Water	E41	-629	-3654	-1607	-613	-945	-791	379	-3637	2178	-1074	-380	-222	-1336	-1087	-463	-416	-6
(3) Q & M Energy Materials	CA	0	-1462	-13299	0	-165	0	0	-5137	338	-64	-74	-448	-1773	-625	0	0	-28
(4) Coke, Refinery, Nuclear	DF	-697	-316	-537	0	-388	0	0	0	1975	250	0	302	0	43	8	-411	0
	Net	-1790	-6926	-17006	-697	-1575	-909	498	-9808	5791	-1852	-1016	-1329	-5035	-5394	-1052	-875	-205
	New							498		5791	250		302		43	8		
Exreaction & Processing																		
(5) Q & M Non-Energy Material	CB	-34	-1042	-200	237	-106	-631	-136	-242	-225	39	371	241	57	-1247	438	-18	-276
(6) Chmicls & Fibres	DG	66	-1086	-179	-403	-1905	611	80	-7353	-2396	-246	102	-156	145	7797	2631	92	98
(7) Rubber & Plastics	DH	90	1463	213	-360	-1852	-226	84	83	696	374	7	269	646	6215	459	769	-13
(8) Non-Metalic Minrls	DI	711	2994	-285	-239	-195	507	484	2459	2607	1347	392	3759	-770	4428	10844	1538	567
	Net	833	2329	-451	-765	-4058	261	512	-5053	682	1514	872	4113	78	17193	14372	2381	376
	new	867	4457	213	237		1118	648	2542	3303	1760	872	4269	848	18440	14372	2399	665
Engineering																		
(9) Basic Metal Prdcts	DJ27	56	857	-7800	224	-1194	684	365	679	1340	472	106	4162	454	5881	3429	-3580	-2961
(10) Fabrctd Metal Prdcts	DJ28	1563	3212	1460	-1863	-6179	-1684	342	-1016	3804	1862	475	2189	-1747	11283	1746	761	253
(11) Machnry Equipmnt	DK	494	2266	1334	997	4983	3394	613	2267	1476	1694	-61	4478	1300	17248	5379	2480	638
(12) Office Machnry, Comptrs	DL30	0	329	4	0	2035	1253	-8	-77	14554	1590	13	1056	1342	11429	820	0	-226
(13) Electrcl Machnry, Apparts	DL31	298	1018	253	-492	-9344	-2868	-306	1691	-7626	-1385	-69	-394	706	-11660	2762	259	59
(14) Medcal Precision Intrmts	DL33	97	310	150	64	1824	170	-38	327	5420	114	76	1651	449	2942	1678	108	64
(15) Motors & Trailers	DM34	1	1361	538	-247	1614	2720	421	-4072	-5011	-42	-15	1891	3023	-203	-8	5	479
(16) Other Transprt.	DM35	123	-268	-232	-108	-1433	74	136	-942	896	323	0	-1670	-89	-438	-402	-104	557
	Net	2632	9085	-4293	-1425	-7694	3743	1525	-1143	14853	4628	525	13363	5438	36482	15404	-71	-1137
	New	2632	9353	3739	1285	10456	8295	1877	4964	27490	6055	670	15427	7274	48783	15814	3613	2465
Other Manufacturing																		
(17) Food, Bevrge & Tobacco	DA	2952	1028	1149	-1434	-280	-2553	765	705	54	-83	459	-6131	-344	12273	493	1774	-204
(18) Textiles	DB17	235	775	500	51	-264	71	-987	-632	1158	554	95	-1860	-3	-9954	4743	366	485
(19) Wearng Apparel	DB18	47	4424	-503	-140	-1077	-604	-3806	-1516	-452	2100	-340	-5123	-1313	8621	-24463	-1228	-3656
(20) Leather & Leather Prdcts	DC	-2	-261	59	-55	34	586	3039	-47	59	4087	-47	1106	2471	-600	34900	1897	3005
(21) Wood Prdcts	DD	-505	-2369	-779	-668	-5338	-2118	-1940	-3408	-6260	-2495	-53	-6155	-2661	-7268	-16116	-4629	-1600
(22) Paper & Paper Prdcts	DE	743	1566	660	-425	188	-210	-36	715	17658	1371	358	1818	147	18934	5463	1039	784
(23) Mncftrg, Jewlery, Musical	DN	-1396	-8851	-1673	-1293	-1861	-2369	-722	-4118	2266	-5559	-1073	-70	-491	1905	-3714	-966	-1829
	Net	2074	-3688	-587	-3964	-8598	-7197	-3687	-8301	14483	-25	-601	-16415	-2194	23911	1306	-1747	-3015
	New	3977	7793	2368	51	222	657	3804	1420	21195	8112	912	2924	2618	41733	45599	5076	4274
	JOB LOSS	-3727	-20803	-28657	-8424	-32603	-14172	-7979	-33231	-21970	-11912	-2674	-23190	-12453	-36807	-45763	-11400	-10970
	NEW JOBS	7476	21603	6320	1573	10678	10070	6827	8926	57779	16177	2454	22922	10740	108999	75793	11088	6989
		3749	800	-22337	-6851	-21925	-4102	-1152	-24305	35809	4265	-220	-268	-1713	72192	30030	-312	-3981

Source :Authors own research. Data from Eurostat.

TABLE 5A.4

REGIONAL MANUFACTURING EMPLOYMENT LOCATION QUOTIENT

ENERGY

	Electr. Gas Steam				Purif distrib water				Q & M Energy Matrls				Coke Refinry Nuclear		
	N16				N17				N11+N13						
	(1)				(2)				(3)				(4)		
	E40				E41				CA				DF		
	1989	1997			1989	1997			1989	1997			1989	1997	
Canarias (IPR)	0.751	0.781	Baleares (IPR)	Canarias (IPR)	0.765	0.747	La Rioja (A) (1)	Asturias (P) (1)	0.940	0.953	Asturias (P) (1)	Canarias (IPR)	0.908	0.762	C-La Mancha (A) (2)
Baleares (IPR)	0.724	0.732	Canarias (IPR)	Galicia (A) (1)	0.700	0.742	Baleares (IPR) *L*	C-Leon (A) (2)	0.810	0.859	C-Leon (A) (2) *H*	Murcia (P) (3)	0.860	0.727	Asturias (P) (1)
Extramedura (P) (2)	0.712	0.669	Extramedura (P) (2)	Extramedura (P) (2)	0.655	0.739	Canarias (IPR) *L*	Aragon (A) (3)	0.623	0.597	Aragon (A) (3)	Asturias (P) (1)	0.855	0.714	Andalucia (P) (2)
Galicia (A) (1)	0.632	0.624	Galicia (A) (1)	C-Leon (A) (2)	0.649	0.697	Andalucia (P) (2) *H*	Galicia (A) (1)	0.429	0.318	Galicia (A) (1)	C-La Mancha (A) (2)	0.809	0.682	Murcia (P) (3)
Aragon (A) (3)	0.597	0.614	Cantabria (A) (1)	Asturias (P) (1)	0.611	0.678	Madrid (C) (2) *L*	Andalucia (P) (2)	0.219	0.254	Andalucia (P) (2)	Andalucia (P) (2)	0.773	0.651	Madrid (C) (2) *N*
Asturias (P) (1)	0.584	0.597	Andalucia (P) (2)	Baleares (IPR)	0.579	0.575	Extramedura (P) (2)	C-La Mancha (A) (2)	0.179	0.250	C-La Mancha (A) (2) *L*	Galicia (A) (1)	0.739	0.539	Pias Vasco (C) (1)
Andalucia (P) (2)	0.570	0.596	Madrid (C) (2)	Andalucia (P) (2)	0.569	0.469	Murcia (P) (3) *L*	Extramedura (P) (2)	0.132	0.104	Madrid (C) (2) *N*	Pias Vasco (C) (1)	0.711	0.535	Galicia (A) (1)
C-Leon (A) (2)	0.539	0.582	C-Leon (A) (2)	Cantabria (A) (1)	0.555	0.445	Galicia (A) (1)	Cataluna (C) (3)	0.073	0.038	Cataluna (C) (3)	Cataluna (C) (3)	0.434	0.305	Cataluna (C) (3)
Madrid (C) (2)	0.524	0.541	Asturias (P) (1)	C-La Mancha (A) (2)	0.550	0.432	C-Valencia (A) (3) *H*	Baleares (IPR)	0.042	0.000	Pias Vasco (C) (1)	C-Valencia (A) (3)	0.379	0.259	C-Valencia (A) (3)
Cantabria (A) (1)	0.522	0.478	Aragon (A) (3)	Aragon (A) (3)	0.509	0.411	Cataluna (C) (3) *H*	Pias Vasco (C) (1)	0.035	0.000	Navarra (A) (1)	Navarra (A) (1)	0.000	0.136	Canarias (IPR)
Cataluna (C) (3)	0.452	0.472	Pias Vasco (C) (1)	Navarra (A) (1)	0.493	0.361	C-La Mancha (A) (2)	Navarra (A) (1)	0.000	0.000	Murcia (P) (3)	Madrid (C) (2)	0.000	0.000	Navarra (A) (1)
C-La Mancha (A) (2)	0.444	0.411	La Rioja (A) (1)	Murcia (P) (3)	0.487	0.284	Pias Vasco (C) (1)	Murcia (P) (3)	0.000	0.000	La Rioja (A) (1)	La Rioja (A) (1)	0.000	0.000	La Rioja (A) (1)
Pias Vasco (C) (1)	0.390	0.390	Cataluna (C) (3)	Madrid (C) (2)	0.396	0.284	Asturias (P) (1)	Madrid (C) (2)	0.000	0.000	Extramedura (P) (2)	Extramedura (P) (2)	0.000	0.000	Extramedura (P) (2)
Murcia (P) (3)	0.338	0.384	Murcia (P) (3)	La Rioja (A) (1)	0.376	0.257	C-Leon (A) (2)	La Rioja (A) (1)	0.000	0.000	C-Valencia (A) (3)	C-Leon (A) (2)	0.000	0.000	C-Leon (A) (2)
C-Valencia (A) (3)	0.307	0.309	C-La Mancha (A) (2)	Cataluna (C) (3)	0.364	0.073	Navarra (A) (1)	C-Valencia (A) (3)	0.000	0.000	Cantabria (A) (1)	Cantabria (A) (1)	0.000	0.000	Cantabria (A) (1)
La Rioja (A) (1)	0.266	0.299	C-Valencia (A) (3)	C-Valencia (A) (3)	0.362	0.031	Aragon (A) (3)	Cantabria (A) (1)	0.000	0.000	Canarias (IPR)	Baleares (IPR)	0.000	0.000	Baleares (IPR)
Navarra (A) (1)	0.244	0.256	Navarra (A) (1)	Pias Vasco (C) (1)	0.337	0.000	Cantabria (A) (1)	Canarias (IPR)	0.000	0.000	Baleares (IPR)	Aragon (A) (3)	0.000	0.000	Aragon (A) (3)

L= initial low level H= initial high level N = New

EXTRACTION AND PROCESSING OF NON-ENERGY-PRODUCING MATERIALS

	Q & M Non-Energy				Chmicls Man Fibres				Rubber Plastics				Non-Metalic Minrls		
	N23				N25+N26				N48				N24		
	(5)				(6)				(7)				(8)		
	CB				DG				DH				DI		
	1989	1997			1989	1997			1989	1997			1989	1997	
Galicia (A) (1)	0.762	0.762	Extramedura (P) (2) *M*	Cataluna (C) (3)	0.630	0.643	Cataluna (C) (3) *H*	Pias Vasco (C) (1)	0.657	0.638	Pias Vasco (C) (1) *M*	C-Valencia (A) (3)	0.659	0.662	C-Valencia (A) (3) *H*
Andalucia (P) (2)	0.634	0.739	Galicia (A) (1) *H*	Madrid (C) (2)	0.617	0.596	Cantabria (A) (1) *M*	La Rioja (A) (1)	0.611	0.615	La Rioja (A) (1) *M*	Canarias (IPR)	0.622	0.599	Canarias (IPR)
Navarra (A) (1)	0.632	0.728	Cantabria (A) (1)*M*	C-Leon (A) (2)	0.590	0.566	Madrid (C) (2) *H*	C-Leon (A) (2)	0.579	0.605	C-Leon (A) (2) *M*	C-La Mancha (A) (2)	0.600	0.586	Galicia (A) (1)*M*
Baleares (IPR)	0.606	0.683	Andalucia (P) (2) *L*	Cantabria (A) (1)	0.574	0.466	C-La Mancha (A) (2) *M*	Cantabria (A) (1)	0.567	0.555	Cataluna (C) (3) *H*	Galicia (A) (1)	0.574	0.582	C-La Mancha (A) (2) *M*
C-La Mancha (A) (2)	0.588	0.628	C-Leon (A) (2) *H*	C-La Mancha (A) (2)	0.483	0.426	C-Leon (A) (2) *M*	Cataluna (C) (3)	0.549	0.549	Cantabria (A) (1) *M*	Andalucia (P) (2)	0.558	0.568	Andalucia (P) (2) *H*
C-Leon (A) (2)	0.580	0.618	C-La Mancha (A) (2) *H*	Pias Vasco (C) (1)	0.408	0.420	Murcia (P) (3) *M*	C-Valencia (A) (3)	0.534	0.502	C-Valencia (A) (3) *M*	Extramedura (P) (2)	0.524	0.542	Baleares (IPR)
Cantabria (A) (1)	0.546	0.547	Murcia (P) (3)	Andalucia (P) (2)	0.406	0.416	Aragon (A) (3) *M*	Madrid (C) (2)	0.488	0.460	Navarra (A) (1)	Cantabria (A) (1)	0.495	0.539	Extramedura (P) (2)
Extramedura (P) (2)	0.540	0.512	Canarias (IPR)	Murcia (P) (3)	0.400	0.412	Andalucia (P) (2) *H*	Navarra (A) (1)	0.486	0.456	Madrid (C) (2)	Baleares (IPR)	0.479	0.529	C-Leon (A) (2)
Canarias (IPR)	0.533	0.482	Asturias (P) (1)	Aragon (A) (3)	0.392	0.384	C-Valencia (A) (3)	Aragon (A) (3)	0.403	0.447	Aragon (A) (3)	Asturias (P) (1)	0.475	0.505	La Rioja (A) (1)
Murcia (P) (3)	0.515	0.466	Navarra (A) (1)	C-Valencia (A) (3)	0.333	0.381	Pias Vasco (C) (1)	Canarias (IPR)	0.400	0.426	Murcia (P) (3)	La Rioja (A) (1)	0.470	0.488	Asturias (P) (1)
Asturias (P) (1)	0.452	0.465	Baleares (IPR)	Galicia (A) (1)	0.306	0.350	Navarra (A) (1)	Murcia (P) (3)	0.327	0.402	Galicia (A) (1)	C-Leon (A) (2)	0.463	0.485	Murcia (P) (3)
Aragon (A) (3)	0.395	0.457	Aragon (A) (3)	Asturias (P) (1)	0.246	0.290	Asturias (P) (1)	Galicia (A) (1)	0.315	0.377	Canarias (IPR)	Aragon (A) (3)	0.452	0.468	Cantabria (A) (1)
Cataluna (C) (3)	0.393	0.455	C-Valencia (A) (3)	La Rioja (A) (1)	0.238	0.281	La Rioja (A) (1)	Andalucia (P) (2)	0.301	0.318	C-La Mancha (A) (2)	Navarra (A) (1)	0.421	0.437	Navarra (A) (1)
C-Valencia (A) (3)	0.391	0.302	Cataluna (C) (3)	Navarra (A) (1)	0.234	0.239	Galicia (A) (1)	C-La Mancha (A) (2)	0.294	0.303	Andalucia (P) (2)	Murcia (P) (3)	0.412	0.382	Madrid (C) (2)
La Rioja (A) (1)	0.388	0.271	Pias Vasco (C) (1)	Canarias (IPR)	0.197	0.205	Canarias (IPR)	Extramedura (P) (2)	0.270	0.263	Extramedura (P) (2)	Cataluna (C) (3)	0.402	0.375	Cataluna (C) (3)
Madrid (C) (2)	0.300	0.254	Madrid (C) (2)	Extramedura (P) (2)	0.102	0.167	Extramedura (P) (2)	Baleares (IPR)	0.207	0.212	Baleares (IPR)	Madrid (C) (2)	0.399	0.364	Aragon (A) (3)
Pias Vasco (C) (1)	0.252	0.175	La Rioja (A) (1)	Baleares (IPR)	0.079	0.145	Baleares (IPR)	Asturias (P) (1)	0.069	0.151	Asturias (P) (1)	Pias Vasco (C) (1)	0.363	0.337	Pias Vasco (C) (1)

TABLE 5A.4
REGIONAL MANUFACTURING EMPLOYMENT LOCATION QUOTIENT

METAL MANUFACTURE: MECHANICAL, ELECTRICAL, AND INDUSTRIAL ENGINEERING

	Basic Metal Prdcts				Fabrctd Metal Prdcts				Machnry Equipm				Office Macnry Comptrs		
					N31				N32				N33		
	(9)				(10)				(11)				(12)		
	DJ27				DJ28				DK				DL30		
	1989	1997			1989	1997			1989	1997			1989	1997	
Asturias (P) (1)	0.888	0.858	Asturias (P) (1)	Pias Vasco (C) (1)	0.699	0.686	Pias Vasco (C) (1)	Pias Vasco (C) (1)	0.711	0.693	Pias Vasco (C) (1)	Baleares (IPR)	0.867	0.781	Madrid (C) (2)
Pias Vasco (C) (1)	0.782	0.795	Cantabria (A) (1)	Cantabria (A) (1)	0.609	0.556	Cantabria (A) (1)	Aragon (A) (3)	0.675	0.633	Navarra (A) (1)	Madrid (C) (2)	0.722	0.578	Navarra (A) (1)
Baleares (IPR)	0.779	0.786	Pias Vasco (C) (1)	Navarra (A) (1)	0.543	0.522	La Rioja (A) (1)	Madrid (C) (2)	0.568	0.624	Aragon (A) (3)	Galicia (A) (1)	0.567	0.562	Cataluna (C) (3)
Cantabria (A) (1)	0.749	0.734	Navarra (A) (1)	Aragon (A) (3)	0.517	0.508	Cataluna (C) (3)	Cataluna (C) (3)	0.535	0.531	Cataluna (C) (3)	Cataluna (C) (3)	0.548	0.535	C-La Mancha (A) (2)
Murcia (P) (3)	0.704	0.480	Galicia (A) (1)	Cataluna (C) (3)	0.503	0.502	Asturias (P) (1)	Navarra (A) (1)	0.522	0.504	Cantabria (A) (1)	C-Valencia (A) (3)	0.493	0.477	Aragon (A) (3)
Navarra (A) (1)	0.690	0.431	Aragon (A) (3)	La Rioja (A) (1)	0.494	0.488	Navarra (A) (1)	Extramedura (P) (2)	0.459	0.503	Murcia (P) (3)	Andalucia (P) (2)	0.469	0.402	Pias Vasco (C) (1)
Galicia (A) (1)	0.423	0.416	Andalucia (P) (2)	Madrid (C) (2)	0.492	0.484	Madrid (C) (2)	La Rioja (A) (1)	0.458	0.485	La Rioja (A) (1)	C-Leon (A) (2)	0.390	0.295	Andalucia (P) (2)
Aragon (A) (3)	0.370	0.357	C-Leon (A) (2)	C-La Mancha (A) (2)	0.439	0.473	C-La Mancha (A) (2)	C-Valencia (A) (3)	0.436	0.465	Madrid (C) (2)	C-La Mancha (A) (2)	0.366	0.228	Baleares (IPR)
C-Leon (A) (2)	0.244	0.335	Cataluna (C) (3)	C-Valencia (A) (3)	0.434	0.469	Extramedura (P) (2)	Murcia (P) (3)	0.369	0.426	C-Valencia (A) (3)	Pias Vasco (C) (1)	0.160	0.224	Galicia (A) (1)
Madrid (C) (2)	0.220	0.331	La Rioja (A) (1)	Murcia (P) (3)	0.425	0.467	Aragon (A) (3)	Cantabria (A) (1)	0.359	0.418	Asturias (P) (1)	La Rioja (A) (1)	0.134	0.205	C-Valencia (A) (3)
Extramedura (P) (2)	0.163	0.292	Madrid (C) (2)	Andalucia (P) (2)	0.422	0.464	Canarias (IPR)	C-La Mancha (A) (2)	0.314	0.370	C-La Mancha (A) (2)	Aragon (A) (3)	0.046	0.045	C-Leon (A) (2)
Cataluna (C) (3)	0.162	0.273	C-Valencia (A) (3)	Extramedura (P) (2)	0.417	0.455	Galicia (A) (1)	Galicia (A) (1)	0.307	0.365	Andalucia (P) (2)	Navarra (A) (1)	0.000	0.034	Extramedura (P) (2)
C-La Mancha (A) (2)	0.094	0.262	Murcia (P) (3)	C-Leon (A) (2)	0.403	0.452	Murcia (P) (3)	Asturias (P) (1)	0.284	0.358	C-Leon (A) (2)	Murcia (P) (3)	0.000	0.004	Asturias (P) (1)
La Rioja (A) (1)	0.036	0.260	Extramedura (P) (2)	Galicia (A) (1)	0.396	0.445	Andalucia (P) (2)	C-Leon (A) (2)	0.262	0.356	Galicia (A) (1)	Extramedura (P) (2)	0.000	0.000	Murcia (P) (3)
C-Valencia (A) (3)	0.000	0.217	C-La Mancha (A) (2)	Asturias (P) (1)	0.374	0.419	C-Valencia (A) (3)	Andalucia (P) (2)	0.255	0.352	Extramedura (P) (2)	Cantabria (A) (1)	0.000	0.000	La Rioja (A) (1)
Canarias (IPR)	0.000	0.072	Baleares (IPR)	Baleares (IPR)	0.352	0.411	C-Leon (A) (2)	Canarias (IPR)	0.105	0.298	Baleares (IPR)	Canarias (IPR)	0.000	0.000	Cantabria (A) (1)
Andalucia (P) (2)	0.000	0.054	Canarias (IPR)	Canarias (IPR)	0.349	0.407	Baleares (IPR)	Baleares (IPR)	0.063	0.227	Canarias (IPR)	Asturias (P) (1)	0.000	0.000	Canarias (IPR)

	Electrcl Machnry Apparat.				Medcal Precsion Instmts				Motor Trailers				Other Tranxprt		
	N34				N37				N35				N36		
	(13)				(14)				(15)				(16)		
	DL31				DL33				DM34				DM35		
	1989	1997			1989	1997			1989	1997			1989	1997	
Madrid (C) (2)	0.651	0.690	Aragon (A) (3)	Cataluna (C) (3)	0.670	0.723	Madrid (C) (2)	C-Leon (A) (2)	0.690	0.747	Navarra (A) (1)	Galicia (A) (1)	0.766	0.775	Galicia (A) (1)
Pias Vasco (C) (1)	0.644	0.637	Cantabria (A) (1)	Madrid (C) (2)	0.668	0.571	Pias Vasco (C) (1)	Aragon (A) (3)	0.675	0.727	Aragon (A) (3)	Andalucia (P) (2)	0.722	0.713	Andalucia (P) (2)
Navarra (A) (1)	0.632	0.584	Madrid (C) (2)	Pias Vasco (C) (1)	0.501	0.533	Cataluna (C) (3)	Navarra (A) (1)	0.669	0.683	C-Leon (A) (2)	Pias Vasco (C) (1)	0.637	0.643	Pias Vasco (C) (1)
Cataluna (C) (3)	0.606	0.571	Pias Vasco (C) (1)	Aragon (A) (3)	0.490	0.475	Andalucia (P) (2)	Madrid (C) (2)	0.577	0.593	Galicia (A) (1)	Canarias (IPR)	0.626	0.637	Canarias (IPR)
Aragon (A) (3)	0.588	0.565	Cataluna (C) (3)	La Rioja (A) (1)	0.450	0.457	Aragon (A) (3)	Galicia (A) (1)	0.566	0.525	Cataluna (C) (3)	Murcia (P) (3)	0.623	0.635	Murcia (P) (3)
Cantabria (A) (1)	0.572	0.509	Navarra (A) (1)	C-Valencia (A) (3)	0.392	0.424	C-Valencia (A) (3)	Cataluna (C) (3)	0.554	0.475	Madrid (C) (2)	Madrid (C) (2)	0.543	0.595	Baleares (IPR)
C-La Mancha (A) (2)	0.458	0.456	C-Leon (A) (2)	Extramedura (P) (2)	0.391	0.360	Extramedura (P) (2)	Cantabria (A) (1)	0.449	0.468	Cantabria (A) (1)	Asturias (P) (1)	0.510	0.581	Asturias (P) (1)
Andalucia (P) (2)	0.316	0.391	C-La Mancha (A) (2)	Canarias (IPR)	0.247	0.284	Navarra (A) (1)	C-Valencia (A) (3)	0.418	0.439	La Rioja (A) (1)	Cantabria (A) (1)	0.400	0.561	Madrid (C) (2)
La Rioja (A) (1)	0.276	0.389	Galicia (A) (1)	Galicia (A) (1)	0.230	0.277	Canarias (IPR)	Pias Vasco (C) (1)	0.352	0.424	Pias Vasco (C) (1)	Baleares (IPR)	0.306	0.424	Cantabria (A) (1)
Extramedura (P) (2)	0.240	0.366	Andalucia (P) (2)	Andalucia (P) (2)	0.226	0.263	Asturias (P) (1)	La Rioja (A) (1)	0.341	0.397	C-Valencia (A) (3)	Aragon (A) (3)	0.303	0.306	Aragon (A) (3)
Galicia (A) (1)	0.237	0.339	C-Valencia (A) (3)	Navarra (A) (1)	0.203	0.259	C-Leon (A) (2)	Andalucia (P) (2)	0.254	0.330	Andalucia (P) (2)	Cataluna (C) (3)	0.273	0.257	La Rioja (A) (1)
C-Leon (A) (2)	0.218	0.317	Asturias (P) (1)	Murcia (P) (3)	0.199	0.247	Galicia (A) (1)	C-La Mancha (A) (2)	0.209	0.222	Baleares (IPR)	C-Valencia (A) (3)	0.239	0.249	Cataluna (C) (3)
C-Valencia (A) (3)	0.170	0.311	Canarias (IPR)	C-Leon (A) (2)	0.190	0.222	Baleares (IPR)	Murcia (P) (3)	0.126	0.197	C-La Mancha (A) (2)	C-Leon (A) (2)	0.217	0.204	C-Valencia (A) (3)
Asturias (P) (1)	0.153	0.259	Extramedura (P) (2)	Asturias (P) (1)	0.178	0.207	Murcia (P) (3)	Extramedura (P) (2)	0.062	0.177	Asturias (P) (1)	La Rioja (A) (1)	0.103	0.174	C-La Mancha (A) (2)
Canarias (IPR)	0.140	0.248	Murcia (P) (3)	Baleares (IPR)	0.102	0.193	Cantabria (A) (1)	Asturias (P) (1)	0.049	0.128	Murcia (P) (3)	Navarra (A) (1)	0.099	0.157	Navarra (A) (1)
Murcia (P) (3)	0.131	0.216	Baleares (IPR)	C-La Mancha (A) (2)	0.053	0.153	La Rioja (A) (1)	Canarias (IPR)	0.049	0.054	Extramedura (P) (2)	C-La Mancha (A) (2)	0.050	0.040	C-Leon (A) (2)
Baleares (IPR)	0.118	0.181	La Rioja (A) (1)	Cantabria (A) (1)	0.037	0.126	C-La Mancha (A) (2)	Baleares (IPR)	0.000	0.044	Canarias (IPR)	Extramedura (P) (2)	0.000	0.000	Extramedura (P) (2)

TABLE 5A.4

REGIONAL MANUFACTURING EMPLOYMENT LOCATION QUOTIENT

OTHER MANUFACTURING

	Food Bevgs Tobac. N41/42 (17) DA				Textiles N43 (18) DB17				Wearng Apparl. N45 (19) DB18		
	1989	1997			1989	1997			1989	1997	
Extramedura (P) (2)	0.695	0.711	Canarias (IPR)	Cataluna (C) (3)	0.729	0.685	Cataluna (C) (3)	C-La Mancha (A) (2)	0.731	0.785	C-La Mancha (A) (2)
Canarias (IPR)	0.687	0.707	Extramedura (P) (2)	C-Valencia (A) (3)	0.600	0.645	C-Valencia (A) (3)	La Rioja (A) (1)	0.688	0.692	Extramedura (P) (2)
Andalucia (P) (2)	0.663	0.663	Murcia (P) (3)	La Rioja (A) (1)	0.557	0.364	La Rioja (A) (1)	Baleares (IPR)	0.674	0.598	Galicia (A) (1)
Murcia (P) (3)	0.641	0.639	Andalucia (P) (2)	Andalucia (P) (2)	0.366	0.356	C-La Mancha (A) (2)	Extramedura (P) (2)	0.664	0.570	Aragon (A) (3)
Cantabria (A) (1)	0.585	0.608	C-Leon (A) (2)	C-Leon (A) (2)	0.292	0.342	Baleares (IPR)	C-Valencia (A) (3)	0.656	0.542	Cataluna (C) (3)
C-La Mancha (A) (2)	0.570	0.608	La Rioja (A) (1)	C-La Mancha (A) (2)	0.287	0.315	Cantabria (A) (1)	Aragon (A) (3)	0.554	0.517	Andalucia (P) (2)
La Rioja (A) (1)	0.570	0.585	Cantabria (A) (1)	Cantabria (A) (1)	0.240	0.311	Murcia (P) (3)	Andalucia (P) (2)	0.549	0.499	Madrid (C) (2)
Navarra (A) (1)	0.563	0.565	Baleares (IPR)	Murcia (P) (3)	0.226	0.304	Galicia (A) (1)	Murcia (P) (3)	0.495	0.469	Murcia (P) (3)
C-Leon (A) (2)	0.563	0.554	C-La Mancha (A) (2)	Galicia (A) (1)	0.224	0.291	C-Leon (A) (2)	Madrid (C) (2)	0.484	0.434	C-Valencia (A) (3)
Baleares (IPR)	0.541	0.546	Galicia (A) (1)	Aragon (A) (3)	0.200	0.289	Andalucia (P) (2)	Cataluna (C) (3)	0.454	0.315	Baleares (IPR)
Galicia (A) (1)	0.540	0.521	Navarra (A) (1)	Navarra (A) (1)	0.179	0.219	Navarra (A) (1)	Galicia (A) (1)	0.422	0.302	C-Leon (A) (2)
C-Valencia (A) (3)	0.439	0.487	Asturias (P) (1)	Pias Vasco (C) (1)	0.139	0.214	Aragon (A) (3)	C-Leon (A) (2)	0.303	0.280	Navarra (A) (1)
Cataluna (C) (3)	0.426	0.439	Cataluna (C) (3)	Extramedura (P) (2)	0.134	0.209	Extramedura (P) (2)	Navarra (A) (1)	0.303	0.277	La Rioja (A) (1)
Aragon (A) (3)	0.424	0.420	Aragon (A) (3)	Madrid (C) (2)	0.091	0.172	Asturias (P) (1)	Asturias (P) (1)	0.222	0.250	Asturias (P) (1)
Madrid (C) (2)	0.421	0.418	C-Valencia (A) (3)	Baleares (IPR)	0.068	0.163	Madrid (C) (2)	Pias Vasco (C) (1)	0.129	0.114	Cantabria (A) (1)
Asturias (P) (1)	0.377	0.388	Madrid (C) (2)	Canarias (IPR)	0.014	0.148	Canarias (IPR)	Cantabria (A) (1)	0.123	0.094	Pias Vasco (C) (1)
Pias Vasco (C) (1)	0.278	0.293	Pias Vasco (C) (1)	Asturias (P) (1)	0.006	0.138	Pias Vasco (C) (1)	Canarias (IPR)	0.057	0.084	Canarias (IPR)

	Wood Prdcts N46 (20) DD				Paper Paper Prdcts N47 (22) DE				Mncftrg Jewelry Musical Furniture (23) DN		
	1989	1997			1989	1997			1989	1997	
Murcia (P) (3)	0.636	0.688	Galicia (A) (1)	Madrid (C) (2)	0.707	0.707	Madrid (C) (2)	Baleares (IPR)	0.680	0.658	Baleares (IPR)
C-Valencia (A) (3)	0.634	0.682	Extramedura (P) (2)	Canarias (IPR)	0.598	0.554	Canarias (IPR)	C-Valencia (A) (3)	0.635	0.641	C-Valencia (A) (3)
Baleares (IPR)	0.632	0.657	Canarias (IPR)	Navarra (A) (1)	0.566	0.543	Cataluna (C) (3)	Murcia (P) (3)	0.612	0.633	Murcia (P) (3)
La Rioja (A) (1)	0.609	0.654	Baleares (IPR)	Cataluna (C) (3)	0.545	0.524	Baleares (IPR)	C-La Mancha (A) (2)	0.583	0.582	La Rioja (A) (1)
C-La Mancha (A) (2)	0.608	0.649	C-La Mancha (A) (2)	Pias Vasco (C) (1)	0.480	0.494	Navarra (A) (1)	La Rioja (A) (1)	0.582	0.551	Andalucia (P) (2)
Galicia (A) (1)	0.605	0.590	C-Valencia (A) (3)	Baleares (IPR)	0.458	0.433	Pias Vasco (C) (1)	Canarias (IPR)	0.579	0.502	Madrid (C) (2)
Canarias (IPR)	0.601	0.567	C-Leon (A) (2)	Aragon (A) (3)	0.450	0.420	C-Valencia (A) (3)	Galicia (A) (1)	0.579	0.490	Aragon (A) (3)
Extramedura (P) (2)	0.556	0.538	Murcia (P) (3)	C-Valencia (A) (3)	0.427	0.407	Murcia (P) (3)	Extramedura (P) (2)	0.528	0.458	Canarias (IPR)
Andalucia (P) (2)	0.497	0.510	La Rioja (A) (1)	Andalucia (P) (2)	0.418	0.393	Andalucia (P) (2)	Andalucia (P) (2)	0.497	0.447	Cataluna (C) (3)
C-Leon (A) (2)	0.490	0.499	Cantabria (A) (1)	La Rioja (A) (1)	0.413	0.387	Aragon (A) (3)	C-Leon (A) (2)	0.464	0.433	C-Leon (A) (2)
Navarra (A) (1)	0.477	0.487	Andalucia (P) (2)	Murcia (P) (3)	0.388	0.379	C-Leon (A) (2)	Navarra (A) (1)	0.457	0.429	Pias Vasco (C) (1)
Aragon (A) (3)	0.459	0.460	Asturias (P) (1)	C-Leon (A) (2)	0.383	0.348	Asturias (P) (1)	Aragon (A) (3)	0.451	0.402	Galicia (A) (1)
Cantabria (A) (1)	0.426	0.432	Aragon (A) (3)	Cantabria (A) (1)	0.350	0.342	Extramedura (P) (2)	Madrid (C) (2)	0.445	0.397	Extramedura (P) (2)
Madrid (C) (2)	0.396	0.427	Navarra (A) (1)	Galicia (A) (1)	0.309	0.342	La Rioja (A) (1)	Cataluna (C) (3)	0.407	0.395	C-La Mancha (A) (2)
Pias Vasco (C) (1)	0.395	0.393	Cataluna (C) (3)	Extramedura (P) (2)	0.297	0.322	Galicia (A) (1)	Cantabria (A) (1)	0.399	0.310	Navarra (A) (1)
Cataluna (C) (3)	0.382	0.357	Pias Vasco (C) (1)	Asturias (P) (1)	0.278	0.293	C-La Mancha (A) (2)	Pias Vasco (C) (1)	0.396	0.235	Asturias (P) (1)
Asturias (P) (1)	0.333	0.288	Madrid (C) (2)	C-La Mancha (A) (2)	0.234	0.224	Cantabria (A) (1)	Asturias (P) (1)	0.309	0.225	Cantabria (A) (1)

TABLE 5A.5
RELATIVE AND ABSOLUTE CONCENTRATION MEASUREMENTS

Amitis Relative / Absolute Concentration Ratios Forslid Absolute Concentration Ratio																		
		Amitis Index of Relative Concentration						Amitis Index of Absolute Concentration						Forslid Index of Absolute Concentration				
		Sr						Sa						Ci				
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
			1997		1989				1997		1989				1997		1989	
Quarrying and Mining of Energy Materials (CA)	Asturias	1	1.572	1	1.531		Asturias	2	1.500	2	1.511		Asturias	2	1.380	2	1.391	
Leather and Leather products (DC)	C.Valencia	2	1.197	12	0.448		C.Valencia	4	1.430	8	1.076	Cataluna	C.Valencia	4	1.305	8	0.901	Cataluna
Office Machinery and Computers (DL30)	Madrid	3	1.004	8	0.523		Madrid	1	1.510	9	1.053	Cataluna	Madrid	1	1.391	9	0.874	Cataluna
Textiles (DB17)	Cataluna	4	0.850	3	1.038		Cataluna	3	1.486	1	1.600		Cataluna	3	1.365	1	1.488	
Basic Metal products (DJ27)	Pias Vasco	5	0.757	2	1.060	Asturias	Pias Vasco	12	0.942	5	1.107		Pias Vasco	14	0.736	5	0.937	
Other Transport (DM35)	Cataluna	6	0.717	6	0.676		Andalucia	14	0.920	14	0.929		Andalucia	16	0.707	14	0.718	
Coke, Refinery, and Nuclear (DF)	Cataluna	7	0.647	4	0.849	Andalucia	Galicia	19	0.829	7	1.093		Galicia	8	0.853	7	0.921	Andalucia
Quarrying and Mining of Non-Energy Materials (CB)	Cataluna	8	0.574	10	0.480	Galicia	Andalucia	20	0.806	19	0.802	Galicia	Andalucia	21	0.551	19	0.545	Galicia
Chemicals and Man Made Fibres (DG)	Cataluna	9	0.550	9	0.484		Cataluna	5	1.225	4	1.110		Cataluna	5	1.075	4	0.941	
Purification and Distribution of Water (E41)	Madrid	10	0.513	16	0.407	Cataluna	Madrid	13	0.937	23	0.724	Galicia	Madrid	15	0.730	23	0.423	Galicia
Medical Precision Instruments (DL33)	Madrid	11	0.510	5	0.696	Cataluna	Madrid	6	1.100	3	1.297	Cataluna	Madrid	6	0.929	3	1.156	Cataluna
Paper and paper products (DE)	Madrid	12	0.455	15	0.407		Cataluna	7	1.060	10	0.987		Cataluna	7	0.882	10	0.793	
Non-Metallic Minerals (DI)	C.Valencia	13	0.432	17	0.375		C.Valencia	18	0.871	17	0.840		C.Valencia	20	0.643	17	0.600	
Electricity, gas and Steam (E40)	Cataluna	14	0.376	23	0.278		Madrid	22	0.778	22	0.758	Cataluna	Madrid	22	0.509	22	0.478	Cataluna
Wood products (DD)	Cataluna	15	0.374	19	0.352	C.Valencia	C.Valencia	21	0.796	20	0.788		C.Valencia	10	0.796	20	0.524	
Wearing Apparel (DB18)	C.la mancha	16	0.361	14	0.411	C.Valencia	Cataluna	10	0.959	16	0.887	C.Valencia	Cataluna	12	0.757	16	0.664	C.Valencia
Electrical Machinery and Apparature (DL31)	Cataluna	17	0.335	7	0.531		Cataluna	8	1.000	6	1.095	Cataluna	Cataluna	9	0.809	6	0.924	
Motors and Trailers (DM34)	Aragon	18	0.332	18	0.372	C.Leon	Cataluna	15	0.914	13	0.950		Cataluna	17	0.700	13	0.746	
Machinery and Equipment (DK)	Pias Vasco	19	0.321	13	0.429		Cataluna	11	0.944	11	0.980		Cataluna	13	0.739	11	0.784	
Manufacturing of jewelry and Musical (DN)	C. Valencia	20	0.306	22	0.319		C.Valencia	16	0.901	18	0.803		C.Valencia	18	0.683	18	0.546	
Food, Beverages, and Tobacco (DA)	Andalucia	21	0.300	21	0.322		Cataluna	23	0.773	21	0.762	Andalucia	Cataluna	23	0.502	21	0.484	Baleares
Rubber and Plastics (DH)	Cataluna	22	0.276	23	0.312	Pias Vasco	Cataluna	9	0.982	12	0.958		Cataluna	11	0.786	12	0.756	
Fabricated Metal products (DJ28)	Pias Vasco	23	0.263	20	0.326		Cataluna	17	0.896	15	0.892		Cataluna	19	0.676	15	0.670	
							Average		1.024		1.000		*Average*		0.848		0.794	

Source: Author's own research

TABLE 5A.6
STANDARDISED RELATIVE AND ABSOLUTE LABOUR-LAND CONCENTRATION VALUES

		Z	Region	Z	Region	Z	Region	Z	Region	LC	Region
ENERGY											
Electricity, gas and Steam (E40)	1997	3.4	Madrid	1.2	Pias Vasco	0.8	Baleares	0.3	Canarias	0.781	Baleares
	1989	3.0	Madrid	1.3	Pias Vasco	0.9	Baleares	0.7	Cataluna	0.751	Canarias
Purification and Distribution of Water (E41)	1997	3.8	Madrid	0.4	La Rioja	0.3	Baleares	0.2	Cataluna	0.747	La Rioja
	1989	2.3	Madrid	1.5	Pias Vasco	0.9	Asturias	0.6	Galicia	0.765	Canarias
Quarrying and Mining of Energy Materials (CA)	1997	4.0	Asturias							0.953	Asturias
	1989	4.0	Asturias							0.940	Asturias
Coke, Refinery, and Nuclear (DF)	1997	3.3	Madrid	1.3	Pias Vasco	0.7	Galicia	0.6	Asturias	0.762	C. La Mancha
	1989	2.8	Asturias	1.3	Pias Vasco	1.8	Murcia	0.4	Cataluna	0.908	Canarias
EXTRACTION AND PROCESSING											
Quarrying and Mining of Non-Energy Materials (CB)	1997	1.8	Galicia	1.8	Cantabria	1.2	Madrid	1.1	Com. Val.	0.762	Extremadura
	1989	2.0	Galicia	1.5	Madrid	1.0	Cataluna	0.8	Pias Vasco	0.762	Galicia
Chemicals and Man Made Fibres (DG)	1997	3.0	Madrid	2.2	Cataluna	0.7	Pias Vasco	0.1	Com. Val.	0.643	Cataluna
	1989	3.2	Madrid	1.7	Cataluna	1.0	Pias Vasco	0.1	Cantabria	0.630	Cataluna
Rubber and Plastics (DH)	1997	3.1	Pias Vasco	1.6	Madrid	1.2	Cataluna	0.4	Com. Val.	0.638	Pias Vasco
	1989	3.4	Pias Vasco	1.3	Madrid	0.8	Cataluna	0.3	Com. Val.	0.657	Pias vasco
Non-Metallic Minerals (DI)	1997	2.8	Com. Valencia	2.0	Madrid	0.9	Pias Vasco	0.6	Cataluna	0.662	Com. Val.
	1989	2.5	Com. Valencia	1.9	Madrid	1.5	Pias Vasco	0.6	Cataluna	0.659	Com. Val.
ENGINEERING											
Basic Metal products (DJ27)	1997	3.7	Pias Vasco	0.9	Asturias	0.4	Cantabria	0.1	Madrid	0.858	Asturias
	1989	3.4	Pias Vasco	1.7	Asturias	0.2	Cantabria	0.2	Baleares	0.888	Asturias
Fabricated Metal products (DJ28)	1997	3.4	Pias Vasco	1.5	Madrid	0.7	Cataluna			0.686	Pias Vasco
	1989	3.6	Pias Vasco	1.1	Madrid	0.4	Cataluna			0.699	Pias Vasco
Machinery and Equipment (DK)	1997	3.4	Pias Vasco	1.3	Madrid	0.8	Cataluna			0.639	Pias Vasco
	1989	3.4	Pias Vasco	1.6	Madrid	0.5	Cataluna			0.711	Pias Vasco
Office Machinery and Computers (DL30)	1997	3.9	Madrid	0.6	Cataluna					0.781	Madrid
	1989	3.4	Madrid	1.5	Baleares	0.5	Cataluna	0.1	Com. Val.	0.867	Baleares
Electrical Machinery and Apparature (DL31)	1997	2.9	Madrid	2.0	Pias Vasco	1.2	Cataluna			0.690	Aragon
	1989	2.6	Madrid	2.5	Pias Vasco	0.9	Cataluna			0.651	Madrid
Medical Precision Instruments (DL33)	1997	3.6	Madrid	1.2	Pias Vasco	0.5	Cataluna			0.723	Madrid
	1989	3.2	Madrid	1.6	Cataluna	1.3	Pias Vasco			0.670	Cataluna
Motors and Trailers (DM34)	1997	2.6	Madrid	1.5	Cataluna	1.4	Pias Vasco	1.0	Navarra	0.747	Navarra
	1989	3.3	Madrid	1.3	Cataluna	0.9	Pias Vasco	0.4	Navarra	0.690	C. Leon
Other Transport (DM35)	1997	2.8	Pias Vasco	2.4	Madrid	0.5	Galicia			0.775	Galicia
	1989	3.2	Pias Vasco	1.9	Madrid	0.5	Galicia			0.766	Galicia
OTHER MANUFACURING											
Food, Beverages, and Tobacco (DA)	1997	2.7	Madrid	1.4	Cataluna	0.8	Canarias	0.7	Pias Vasco	0.711	Canarias
	1989	2.8	Madrid	1.0	Cataluna	0.8	Pias Vasco	0.5	Com. Val.	0.695	Extremadura
Textiles (DB17)	1997	3.4	Cataluna	1.8	Com. Val.	0.1	Madrid			0.685	Cataluna
	1989	3.7	Cataluna	1.2	Com. Val.	0.2	La Rioja			0.729	Cataluna
Wearing Apparel (DB18)	1997	3.2	Madrid	1.9	Cataluna	0.5	Com. Val.	0.1	Galicia	0.785	C. La Mancha
	1989	2.6	Madrid	2.1	Com. Val.	0.9	Cataluna	0.7	La Rioja	0.731	C. La Mancha
Leather and Leather products (DC)	1997	3.5	Com. Valencia	1.0	Baleares	0.9	La Rioja	0.1	Madrid	0.809	Com. Val.
	1989	2.6	Madrid	1.8	Com. Val.	1.7	Cataluna	0.2	Murcia	0.665	Com. Val.
Wood products (DD)	1997	2.3	Com. Valencia	1.4	Pias Vasco	1.2	Madrid	0.9	Cataluna	0.688	Galicia
	1989	2.1	Com. Valencia	1.8	Madrid	1.8	Pias Vasco	0.4	Cataluna	0.636	Murcia
Paper and paper products (DE)	1997	3.8	Madrid	0.7	Cataluna	0.5	Pias Vasco			0.707	Madrid
	1989	3.6	Madrid	1.0	Pias Vasco	0.6	Cataluna			0.707	Madrid
Manufacturing of jewelry and Musical (DN)	1997	2.7	Madrid	1.7	Com. Val.	1.2	Pias Vasco	0.7	Cataluna	0.658	Baleares
	1989	2.2	Madrid	1.9	Com. Val.	1.6	Pias Vasco	0.7	Baleares	0.680	Baleares

Source: Author's own research

Regional Industry Index of Similarity / Diversity

In order to compare industry localisation (structures) between regions, Krugman (1991a) suggests a method for developing an index of regional divergence / similarity. The share of industry i in total manufacturing employment in region j is given by s_{ij}, a ratio defined as;

$$s_{ij} = \frac{R_j^{ei}}{R_j^{me}} \qquad (5B.1)$$

where s_{ij} refers to industry i in region j, and $i \neq j$. This calculation is made for all industries in a particular region j. The industry structure of a region is determined by the type and number of industries within a region and the respective share of manufacturing employment s_{ij} in each industry type. The region with which the comparison is made is labelled s_{ij}^{*}. Krugman then constructs the divergence / similarity index

$$I = \sum_j^i \left| s_{ij} - s_{ij}^{*} \right| \qquad (5B.2)$$

and indicates that if two regions have an identical (similar) industry structure, 'that is, that industry shares of employment were the same for all i, then the index would be zero. If two regions had completely disjointed industry structures, the index would be 2 (because each share in each region would be counted in full)'.[75] The index quantifies the difference or similarity in regional industry structure, and hence regional specialisation.

The construction of Krugman's similarity / divergence index consists of two steps. First, calculate regional industry employment as a share of total regional industry employment. Second, chose a reference region $r^* = 1$ and compare its industry structure to all other R – 1 regions by subtracting the R regions respectively from the reference region. The index I is obtained by summing the absolute differences. Each region is, in its turn, used as a reference region so that a symmetric R*R matrix of similarity / divergence index values is obtained. Its diagonal value is zero.

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[75] Krugman (1991a).,*Opt. Cit.*, p. 76

TABLE 5.C.1
A COMPARISON OF CONCENTRATION MEASUREMENTS

	*Krugman**	*Amiti*	*Amiti*	*Forslid*	*Brand*
Cap Cluster Pias Vasco	$0.5 < LG_{ij} < 1$	$S^R > 1$	$S^A > 1$	$C_i > 1$	L_{IJ} †
Quarrying & mining of energy materials	CC	CC	CLC	CLC	CC
Basic metal products	CLC		CD < 1		CC
Machinery and equipment	CLC				CC
Fabricated metal products	CLC				CLC
Rubber and Plastics	CLC				CLC
Other transport	CC				CD
Quarrying and mining of non-energy	NC				DMD
CAP Cluster Madrid					
Office machinery and computers	CLC	CC	CC	DC > 1	CC
Medical precision instruments	CC		CLC	CD < 1	CC
Paper and paper products	NC		DC > 1		CC
Chemicals and man made fibres	CC		CC	DC > 1	CD
Motors and trailers	CC				CD
Coke, refinery and nuclear energy	CLC		CD < 1		DC
Wearing apparel	CC				DC
Electrical machinery and apparatus	CC		CLC		DLD
Food, beverage and tobacco	CC				DMD
Manufacture of jewellery and musical	CLC				DLD
Electricity, gas and steam	CC				DC
Purification and distribution of water	CLC				DC
CAP Cluster Cataluna					
Textiles	CLC		CLC	CLC	CLC
Leather and leather products	CC	CC	CC	DC > 1	DC
Wood products	CC				DLD
Non-metallic minerals	CC				DLD

Source: Author's own research.
† $CC = L_{ij} > 3\sigma$; $CD = L_{ij} > 3\sigma \rightarrow 3\sigma < L_{ij}$; $DC = 3\sigma < L_{ij} \rightarrow L_{ij} > 3\sigma$; $DD = DLD = DMD < 3\sigma$.
* Taken from Table 5.10.

CHAPTER 6

SPATIAL CORRELATION ANALYSIS OF THE SPANISH CAP CLUSTERS

6.1 INTRODUCTION

In the new economic geography theory trade liberalisation releases agglomeration and dispersion forces that endogenously determined the location of manufacturing production (Krugman, 1991b). The increase in market size and competition causes firms and industries (n) to locate closest to their largest markets to achieve economies of scale in production. Labour (L) relocation and migration to larger markets is motivated by higher nominal and real wages. This study has demonstrated that firms, industries and labour in the Spanish CAP regions have responded to trade liberalisation according to the new economic geography theory.

The objective of this chapter is to continue the analysis of the workings of the endogenous mechanisms within the 'black-box' of the new economic geography by examining the effects of agglomeration and dispersion forces on the microeconomic variables at the firm level in the regions of the respective CAP clusters. Strong agglomeration and dispersion forces in the regions creates a demand for labour, bidding up wages (w), and increases gross investment (K) to achieve economies of scale in production. Increased competition changes production structures, stimulating a more efficient use of labour per firm (L/n) and achieving higher productivity levels through increased capital investment per employee (K/L). Strong agglomeration forces result in a divergence of these economic variables, while strong dispersion forces result in a convergence of variables.

To examine the strengths of these 'black-box' forces, spatial correlation analysis is used to measure the influence of economic activity between the core and adjacent regions, the core and periphery regions, and the adjacent and periphery regions. If the home market effect (agglomeration) prevails, there is a divergence in the values of economic variables. If, on the other hand, the competition effect (dispersion) prevails, a convergence in the values of economic variables occurs (Krugman, 1991b).

The chapter is divided into two main sections. Section 6.2 discusses the spatial correlation coefficient and examines the empirical results for the CAP model. In Section 6.3 a spatial correlation analysis is conducted for the Spanish border regions and its foreign adjoining regions. The conclusion of the spatial correlation analysis is discussed in Section 6.4.

6.2 THE SPATIAL CORRELATION COEFFICIENT

This section examines the extent to which agglomeration and dispersion forces have influenced the development of economic variables between the regions. The spatial correlation coefficient is defined by the following statistical measurement:

$$c_k = \frac{\sum_{r=1}^{R}\sum_{i_{kr}}^{I_{kr}}(x_r - x_{i_{kr}})^2}{2I_k} \bullet \frac{R-1}{\sum_{r=1}^{R}(x_r - \overline{x})^2} \tag{6.1}$$

Where x is the value of a demographic or economic variable in region r ($r = 1,\ldots, R$) and the statistic c_k is called a contiguity coefficient. Spatial correlation analysis is based on the concentric circle theory of the CAP model. The contiguity coefficient captures the strength of the spatial correlation of an economic variable between the core and an adjacent region in the first concentric circle ($k = 1$), and the core and the periphery region in the second concentric circle ($k = 2$).

Spatial correlation analysis measures the correlation between the observations on one single variable dispersed over different regions. A positive correlation exists when the contiguity coefficient exhibits a value $0 < c_k < 1$. Consequently, the closer the value lies to zero, the stronger the relationship between the values in a variable in two different regions, the more they have converged. A negative correlation exists when the value of $c_k > 1$. A negative value of the contiguity coefficient indicates that the values of the variable in the two different regions are moving in the opposite direction i.e. divergence. When the correlation coefficient shows a value $c_k = 1$, there is no correlation between the values of a variable in the two different regions. (See Chapter 6, Appendix 6A, for a complete specification of the spatial correlation coefficient and its properties).

6.2.1 Empirical Estimation

This analytical method uses the available economic variables of the regions in the respective CAP clusters to provide three separate samples and unique calculations for the Spanish regions. As a result of the varying number of regions within a CAP cluster, the sample sizes can differ. The k-order-connections between the regions are presented in Table 6C.2 (See Chapter 6, Appendix 6C). The economic, demographic, and manufacturing data has been categorised according to CAP-region classification in Table 6C.3 (See Chapter 6, Appendix 6C). This data is used to elucidate the estimated contiguity coefficients.[76]

Spatial correlation analysis is utilised to examine the relationship between the economic variables of the CAP clusters of regions. The analysis examines the spatial relationship between the following regional variables; per capita income (Y/P), total population (P), the total number of firms (n), the total number of manufacturing employees (L), the ratio of manufacturing employment to population (L/P), total wages and salaries (w), total gross investment (K), the average number of employees per firm (L/n), the average gross investment per firm (K/n), the average gross investment per employee (K/L), the average wage per employee (*w/L*), and the average wage costs per firm (*w/n*). By focusing on the relationship between economic variables, this analysis illuminates the extent to which agglomeration and dispersion forces have influenced the development of these variables between regions.

Cross-sectional data is used for 1989 and 1997. The economic and demographic variables (*Y/P*) and (*P*) respectively are disaggregated data per region *j*. The economic variables[77] pertaining to manufacturing are aggregated across all industries *i*, per region *j*. Table 6.1a reports the empirical results of the spatial correlation analysis. This analysis studies the contiguity values of the twelve variables for a *first-order* contiguity relationship between the core and adjacent regions, and the adjacent and periphery regions. The *second-order* contiguity relationship pertains to the core and periphery regions.

TABLE 6.1a

SPATIAL CORRELATION COEFFICIENTS FOR THE CAP REGIONS IN SPAIN

		Contiguity Order: $k = 1,2$					
		1 Core-Adjacent		2 Core-Periphery		1 Adjacent-Periphery	
	Variables	*1989*	*1997*	*1989*	*1997*	*1989*	*1997*
1	Per Capita Income (Y/C)	1.370	1.350	1.708	1.747	0.607	0.826
2	Population (P)	0.851	0.838	1.208	0.768	0.637	0.626
3	Number of Firms (n)	0.582	0.667	0.933	0.770	0.786	0.593
4	Number of Manufacturing Employees (L)	0.986	0.922	1.081	0.963	0.790	0.698
5	Manufacturing Employees / Population (L/P)	0.389	0.500	0.473	0.821	0.630	0.643
6	Wages and Salaries (w)	1.296	1.159	1.173	1.058	0.916	0.827
7	Gross Investment (K)	1.047	1.132	0.387	0.951	0.792	0.825
8	Average Number of Employees per Firm (L/n)	2.035	0.284	0.966	0.346	0.605	0.161
9	Average Gross Investment per Firm (K/n)	1.954	0.347	0.983	0.211	1.064	0.257
10	Average Gross Investment per Employee (K/L)	1.458	0.626	0.557	0.599	1.089	1.443
11	Average Wage per Employee (w/L)	1.544	0.606	1.295	0.925	0.499	0.393
12	Average Wage Costs per Firm (w/n)	2.089	0.309	1.049	0.359	0.560	0.335

Source: Authors own calculations / Contiguity Analysis / Excluding the Island Regions

The complement of the spatial correlation coefficient is given by the coefficient δ_k, which is defined as:

$$\delta_k = 1 - c_k$$

Where, δ_k is the *coefficient of spatial influence*. If, $\delta_k = 0$, there is no spatial correlation; if $\delta_k > 0$ a positive spatial correlation is present, and if $\delta_k < 0$, the spatial correlation effect is negative. The values of the corresponding coefficients of spatial influence are presented in Table 6.1b. (See Chapter 6, Appendix 6C, for an explanation of the method and its application).

[76] An example of how the spatial correlation is calculated is presented in Chapter 6, Appendix 6B, *'Calculating the Spatial Correlation Coefficient.'* The author of this study has outlined a seven-step method to calculate the contiguity coefficient using the data from an example for the Netherlands by Paelinck and Nijkamp (1975).

[77] The values of these variables are found in Table 6A.3, located in Appendix 6A of Chapter 6.

TABLE 6.1b

COEFFICIENT OF SPATIAL INFLUENCE FOR THE CAP REGIONS IN SPAIN

		CONTIGUITY ORDER: k = 1,2											
		1 CORE - ADJACENT				2 CORE - PERIPHERY				1 ADJACENT - PERIPHERY			
	VARIABLES	*1989*	*t*	*1997*	*t*	*1989*	*t*	*1997*	*t*	*1989*	*t*	*1997*	*t*
1	Per Capita Income *(Y / P)*	-0.370		-0.350		-0.708	2	-0.747	1	0.393		0.174	
2	Population *(P)*	0.149		0.164		-0.601		0.675		0.363		0.374	
3	Number of Firms *(n)*	0.418		0.333		0.067		0.230		0.214		0.407	
4	Nr. of Manufacturing Employees *(L)*	0.014		0.078		-0.081		0.037		0.210		0.302	
5	Manufacturing Employees/Population *(L / P)*	0.611	3	0.500	3	0.527	3	0.179		0.370		0.357	
6	Wages and Salaries *(w)*	-0.296		-0.159		-0.173		-0.058		0.084		0.173	
7	Gross Investment *(K)*	-0.047		-0.132		0.613	3	0.049		0.208		0.175	
8	Avg. Nr. of Employees per Firm *(L / n)*	-1.035		0.716	1	0.034		0.654	2	0.395		0.839	1
9	Avg. Gross Investment per Firm *(K / n)*	-0.954	1	0.653	2	0.017		0.789	1	-0.064		0.743	1
10	Avg. Gross Invest. per Employee *(K / L)*	-0.458	3	0.374		0.443	3	0.401		-0.089		-0.443	3
11	Avg. Wage per Employee *(w / L)*	-0.544	3	0.394		-0.295		0.075		0.501	3	0.607	3
12	Avg. Wage Costs per Firm *(w / n)*	-1.089		0.691	2	-0.049	3	0.641	2	0.440	3	0.665	2

Legend: Level of significance. 1 is $\alpha = 0.01$; 2 is $\alpha = 0.05$; 3 is $\alpha = 0.10$.

The correlation values between the regional variables have been tested for their statistical significance with the following *t*-test statistic:

$$t = \frac{r - \rho}{\sqrt{\frac{1 - r^2}{n - 2}}}$$

Where, the test statistic, *t*, follows a *t* distribution with $n - 2$ degrees of freedom, *r* is the correlation value, ρ the symbol for the Null Hypothesis such that $\rho = 0$ or the Alternative Hypothesis, $\rho \neq 0$. The *t*-test significance level, α, of a correlation is given in the column next to the correlation, and is represented with a number ranging from 1 to 3.

6.2.2 Core-Adjacent Regions Contiguity Coefficients

The estimated spatial correlation coefficients for the core-adjacent regions represent a *first-order connection* of regions $k = 1$, and therefore a first-order contiguity coefficient. The sample of regions for this estimation consists of the three core regions and their immediate adjacent regions. The estimated coefficients enable us to make a number of observations on the empirical results in Table 6.1a.

First, the first-order contiguity coefficients between the core and adjacent regions for the year 1989 reveal a tendency towards a negative spatial correlation for eight of the twelve variables. A negative correlation indicates a dissimilar value of the variable between the regions. For example, the variable per capita income with a high value in Madrid is correlated with a low value of the corresponding variable in its adjacent regions Castilla Leon and Castilla La Mancha (see Table 6A.3). A positive spatial correlation is found for the 2^{nd}, 3^{rd}, 4^{th}, and 5^{th} correlations, indicating that these variables in the adjacent regions have similar values as those in the core regions. The negative spatial correlations in 1989, for variables six through twelve are signals of microeconomic variable divergences in manufacturing production and cost-structures between the core and adjacent regions.

In 1997, the pattern is reversed with nine of the twelve contiguity coefficients indicating a positive value. The microeconomic ratios show a strong convergence of variable values between the core and adjacent regions. However, the 1st, 6th, and 7th correlations continue to show a negative value. The contiguity coefficient values for the variables per capita income, total wages and salaries paid in the manufacturing sector, and gross investment remained negative in 1997. This points to an uneven development of these three variables in the core and adjacent regions. This result is informative, since the data reveals a stronger growth in the core than the adjacent regions, ensuring the continuity of the negative values of the contiguity coefficients.

Second, a further inter-temporal comparison of the first-order contiguity coefficients for the core and adjacent regions reveals a marginal deterioration in the positive contiguity coefficients for two variables; the number of firms (n), and the ratio of manufacturing labour to total population (L/P). This development can be combined with the three negative spatial correlations to explain the attraction function of the core regions and the cumulative causation process of agglomeration. Relatively more firms (n) located in the core, which attracted relatively more manufacturing employees (L) and their families than the adjacent regions. The relative increase in firms resulted in relatively higher total wage and salary (w) disbursements to labour. The forces of imperfect competition, in tandem with a relatively higher growth of the number of firms, led to a relatively higher level of gross investment (K) in the core regions (Krugman, 1991b). The diminishment of the coefficient is due to the abnormally high gross investment in the core region of Cataluna versus the other core and adjacent regions. In fact, gross investment in Cataluna was three times that of the levels observed in the remaining two core regions, and, on average, four times that seen in the adjacent regions. This development clarifies the divergent industry structure between Cataluna and its adjacent regions. Cataluna experienced strong agglomeration effects with a divergent outcome in its adjacent regions.

Third, the strong convergence of the 8th through 12th first-order contiguity coefficients in 1997 cast light on the strength of the competition effect in eliminating the wide disparities in manufacturing cost and production structures between the core and adjacent regions, as was evident in 1989. There was a strong convergence between the core and adjacent regions with respect to the average number of employees per firm (L/n), and average wages per employee (w/L). This outcome captures the increased similarity in average production cost and production structures within the core and adjacent regions. The average number of employees per firm in 1997 in the core and adjacent regions was 17.9 and 18.1 respectively, in contrast to 21.2 and 12.2 in 1989. This outcome points to the rationalization in manufacturing's use of labour. The average wages per employee in the adjacent regions changed relatively more than in the core regions, but remained at a lower level. In the core regions, average manufacturing wages increased by €3,500 from €14,908 in 1989 to €18,420 in 1997, while in the adjacent regions average wages increased by €5,300 from €10,951 in 1989 to €16,280 in 1997. The combined effects of increased similarity in labour inputs per firm and the strong relative growth of average manufacturing wages in the adjacent regions resulted in the strong convergence of average wage costs per industry (Venables, 1994).

In 1989, average gross investment per firm (*K/n*) in the core regions exceeded that of the adjacent regions by an average factor of two, resulting in a strong negative spatial correlation value. In 1997, the contiguity coefficient shows a very strong convergence in the values of this variable between the core and adjacent regions. Although the average levels of gross investment per firm, between the two region types, are almost identical, the rate of change is substantially higher in the adjacent regions. This outcome provides insight, since it reveals a 'catch-up' effect to achieve economies of scale in production. This further suggests that the cumulative process of agglomeration has increasingly been fortified in the adjacent regions, with the rate of return on capital being relatively higher, offsetting market access costs (Venables, 1994 and 2000). Finally, the 'catch-up' effects in average wages (*w/L*) and average gross investment per firm (*K/n*), in the adjacent regions, leads to the conclusion that the competition effect is dispersing economic activity, from the core to the relatively lower cost adjacent regions, leading to a convergence in the values of these variables between these regions. Average wages remained relatively lower in the adjacent regions in 1997. The outcome of the industry index analysis showed a greater similarity in industry structures between core and adjacent regions. The spatial correlation analysis confirms this convergence on the microeconomic level.

6.2.3 Core-Periphery Regions: Contiguity Coefficients

This analysis identifies the periphery regions associated with each of the core regions in Spain. Since a periphery region is connected to an adjacent region and theoretically represents a region in the second-ring of regions around the centre, it is considered to be a *second-order connection,* such that $k = 2$. The estimated spatial correlation between the core and periphery regions is therefore a second-order contiguity coefficient. The sample of regions for this estimation is composed of the three Spanish core regions and the respective periphery regions associated with each core. The core region with which they are associated is determined by the distance criteria. For example, Extremadura and Andalucia are identified as periphery regions associated with the core region of Madrid; Murcia is allied with the core region of Cataluna, and Galicia and Asturias are associated with the core region of Pias Vasco.

First, the second-order contiguity coefficients for 1989 indicate assorted values. Six of the twelve estimates display a negative correlation. However, a positive correlation is found for the 3rd, 5th, 7th, 8th, 9th, and 10th correlations. In 1997, ten of the twelve correlation estimates exhibit a positive value. This outcome proves a degree of convergence between these regions. However, the 1st and 6th correlations continue to show a negative value. The contiguity coefficient values for the variables per capita income (*Y/P*), and total wages/salaries (*w*) remained negative in 1997, indicating a continued dissimilarity in the value of these variables between the core and periphery regions. The interaction between these variables captures the convergence of per capita incomes, within the sample of periphery regions; however, the absolute levels remain well below that of the core regions. Between 1989 and 1997, the growth of manufacturing income (wages and salaries), in the core regions, exceeded that of the periphery regions. This outcome is manifested in the uneven development of this variable between the two regions, i.e. a continued negative correlation value. It indicates a relative wage cost advantage for the periphery regions (Venables, 1994).

Second, an inter-temporal comparison of the second-order contiguity coefficients for the core and periphery regions indicates a substantial (more than fifty-percent) deterioration in the positive values of the spatial correlation coefficients for the variables gross investment (*K*), and the ratio of manufacturing labour to total population (*L/P*). In the case of the former, the increased disparity is caused by the relatively larger growth in gross investment in the periphery regions although their absolute levels remain lower than in the core regions. This suggests high rates of return on capital formation in the periphery regions (Venables, 2000). For the latter variable, (*L/P*), the deterioration is caused by the decline in manufacturing employment in the periphery regions versus an increase in the core regions. This increase is evidence of the home market effect, i.e. labour migration in response to higher wages in the core regions (Krugman, 1991b) Industry concentration analysis has shown the strong economic geography effects resulting in absolute and relative concentration of industry in core regions that underlie this signalled discrepancy.

In 1997, the 2nd, 3rd, and 4th second-order contiguity coefficient values capture an unexpected improvement over those of 1989. All three correlations are positive, indicating a convergence of values of these variables in the core and periphery regions.[78]

The positive change in the population correlation, (*P*), is due to the marginal convergence of variable values between Pias Pasco, Galicia and Asturias. Population decline in Galicia and Asturias is more than twice that of Pias Vasco, thereby reducing the disparity between the values of this variable. In the periphery region of Murcia, population increased, while that of the core region Cataluna declined. This factor caused the variable values to converge. Between the core region Madrid and its periphery regions Extremadura and Andalucia, there were offsetting values in the change of population variable values. This resulted in an almost constant difference versus 1989.

The strengthening of the correlation for the variable number of firms (*n*) from 0.933 to 0.770 is due to developments in two periphery regions. First, the periphery region of Galicia has experienced a substantial reduction in the number of its firms[79]. This factor caused a strong convergence in variable values with Pias Vasco. Second, the periphery region of Andalucia has also seen a significant reduction in the number of its firms. Of particular interest is the fact that the variable value became almost identical to

[78] It is important to note that the relationship between the core regions and their respective periphery regions is the only variable being measured, and not all second-ring regions around the core. The adopted procedure allows for a more accurate detection of nuances in the development of the regional variables. In light of this procedure, the reasons for the strengthening of these three correlations can be explored.

that of the core region, Madrid, which saw an increase in the number of its firms in 1997. This fact is of interest since it reflects symmetry in the number of firms between a core and a periphery region. This study has posited that periphery regions have a lower concentration of manufacturing activity than a core region. This finding contradicts our assumption and warrants further investigation into the economic developments in Andalucia[80]. In Andalucia, firms are spread out over a larger geographic area because of its many population centres. Finally, the decline in the number of firms in the periphery regions of Asturias and Extremadura contributed to narrowing the discrepancies between contiguity values.

The contiguity coefficient for the variable number of manufacturing employees (*L*) turned positive in 1997 from its negative value in 1989. This marginal improvement is due to two developments in the periphery regions around the core region of Pias Vasco. First, in comparison to the decline in the periphery region of Asturias, Pias Vasco also experienced a substantial out-migration of its manufacturing employees, as revealed in Section 5.5.1of this study. Second, this substantial decline was offset by an increase in the number of manufacturing employees in the *ex ante* border periphery region of Galicia, resulting in a marginal improvement in the contiguity value.

The contiguity coefficients for the microeconomic variables 8 to 12 indicate significant improvements over their 1989 values. The rationalization of production, as indicated by the average number of employees per firm (*L/n*), also extended to manufacturing production in the periphery regions. There was a noticeable convergence in the value of this variable between the core and periphery regions. The ratio measuring the average number of employees per firm (*L/n*) changed to 0.346 in 1997 from a high of 0.966 in 1989. This result exemplifies the competition effect on cost minimisation within firms (Baldwin *et al.*, 2002) and the need to increase efficiency in production to compensate for the distance from core regions (Venables and Limao, 2002).

The variable average gross investment per firm (*K/n*) shows the strongest improvement. The high levels of gross investment per firm, in the respective periphery regions, are the source of this development. The most noteworthy development is found in Pias Vasco and its periphery regions. Of the three core regions, Pias Vasco experienced the highest level of gross investment per firm. Its periphery region of Galicia experienced an increase by a factor of 1.2 the level of Pias Vasco, while in Asturias the variable increased by a factor of 2.4 that of Pias Vasco. These outcomes in the CAP cluster of Pias Vasco are due to location of medium and high growth export industries requiring medium internal returns to scale and medium levels of capital intensity. In the periphery region of Murcia, average gross investment per firm exceeded that of the core region Cataluna by a factor of 5.3. Murcia experienced an increase in

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[79] This reduction could be due to mergers. This would be the case if the number of manufacturing employees in the region remained constant or even increased.

[80] The geographic area of the region of Andalucia is 87.3 thousand square kilometres with a total population of 7,1 million, and population density of 81.3 / km^2. It consists of 57 urban areas of which nine have a population of greater than 100,000, but less than 500,000. It has an urban population concentration of 36.6%, with 57% of its land use for agricultural production. The geographic area of the region of Madrid is 8 thousand km^2 with a total population 5,028 million, and a population density of 629

new firms in the Extraction and Processing and Engineering sector. The decline in average gross investment per firm in the core region of Madrid and its periphery region of Extremadura was offset by substantial increases in the Engineering sector in the periphery region of Andalucia. These outcomes are informative, since they lead to the conclusion that the coastal-periphery regions are expanding physical plant capacity to acquire economies of scale in production.

By doing so, they are attaining the objective of the new regional policy. Regional policy encouraged investment into profitable and self-sufficient production activities in order to increase the periphery region's levels of economies of scale (Venables, 2000). This would help to eliminate economic disparities between periphery and central regions (Doyle, 1989). We may further conclude that the cluster of regions around the core region of Pias Vasco is clearly a developing economic region. The high levels of average gross investment per firm in the adjacent regions of Pias Vasco support this conclusion. The home market effect is very strong in this cluster of regions for industries with a low demand bias (Midelfart *et. al.*, 2000).

The variable average gross investment per employee (*K/L*), although positive, shows marginal deterioration versus its 1989 value. This weakening is caused by the fact that, in general, the average levels of gross investment per employee in the periphery regions continued to exceed that of the core regions in 1997. The level of average gross investment per employee in Galicia and Asturias exceeded that of Pias Vasco respectively by a factor of 1.3 and 3.2. A similar pattern is found in the periphery region of Andalucia, in which average gross investment per employee exceeds that in the core region of Madrid by a factor of 2.5. Finally, average gross investment per employee in Murcia was five times that of the core region Cataluna. These outcomes are consistent with the goals of regional policy to encourage new and existing firms – intermediate and final goods producers – in the periphery regions to become more capital intensive to enhance their economies of scale in production[81].

The contiguity coefficient on the 11th variable, average wage per employee (*w/L*) reveals a particularly interesting development for a second-order contiguity coefficient. The negative value of this correlation in 1989, signals a divergence in the value of average wage per employee between the core and periphery regions at that time. In 1997, however, this contiguity coefficient turned positive, indicating a convergence, however slight, between average wages per labour in the core and periphery regions.

The data reveals that of the three core regions, the core region of Pias Vasco experienced the largest increase in average wage per employee. This increase was paralleled by an equal increase in the periphery region of Asturias, and a higher increase in the periphery region of Galicia. This finding represents a strong convergence of average wage per labour between a core and periphery regions. The same phenomenon is also evident between the core regions of Madrid and its two periphery regions of

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/km^2. The region of Madrid has fifteen urban areas of which six have a population greater than 100,000, with an urban population density of 89.3%. The land use in the region of Madrid is 51% agriculture.

Extremadura and Andalucia. Although the absolute levels in the periphery regions remained lower than that of the core region, their rates of change were larger than that of the core region. The data reveals that reason for the positive direction of this second-order contiguity coefficient is primarily due to the convergence of average labour wages in the core and periphery regions of the Pias Vasco cluster. The higher average wages in the CAP cluster Pias Vasco is explained by the characteristics of growing export industry's need for skilled employees (Midelfart *et. al.,* 2000). The outcome is an example of the workings of the competition effect (Venables, 1994; Krugman and Venables, 1996; Baldwin *et al.,* 2002)

Finally, average wage costs per firm (*w/n*) in the periphery regions converged significantly with those in the core regions. This convergence turned the spatial correlation from a negative value, in 1989, to a very strong positive value in 1997. In general, the absolute levels of average wage costs per firm remained lower in the periphery regions than their respective core regions. However, the rates of change in the periphery regions exceeded those of the respective core regions. Once again, the increase in average wage costs per firm in the periphery regions of Asturias and Galicia were more than twice those of Pias Vasco. The diminishing value of this variable in Madrid was offset by respective comparable individual increases in its periphery regions. The rate of change in the periphery region of Murcia also exceeded that of Cataluna, although its absolute level remained almost half of that of the core region.

6.2.4 Adjacent-Periphery Regions: Contiguity Coefficients

The study has thus far examined the economic relationship between the core and adjacent regions, and the core and their respective periphery regions. The existence of economic influences between the adjacent and periphery regions is assumed by virtue of proximity. Periphery regions are connected to adjacent regions and thus have a *first-order connection.* The strength of this spatial influence can be captured in a first-order contiguity coefficient. The results of this estimation are listed in the most right hand column of Table 6.1a.

First, the first-order contiguity coefficients in 1989 show a tendency towards a positive relation, except for the 9th and 10th coefficients, which are negative. In 1997, eight of the twelve variables showed a convergent relationship, while the 1st, 5th, 7th, and 10th variables diverged. Per capita income (*Y/P*) in the adjacent regions grew relatively faster than in the periphery regions. The labour force population ratio (*L/P*) indicates a marginal decline. The divergence in gross investment (*K*) reflects the relatively higher levels of this variable in the periphery regions versus the adjacent regions. Also, the strong significant divergence – at the $\alpha = 0.10$ level – of average gross investment per employee (*K/L*) signifies the relatively larger changes in the periphery regions. These developments signal a level of capital formation that exceeds that of the adjacent regions. It suggests a 'catching-up' effect in the creation of scale

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[81] See Table 5.2 'Regional Distribution of New Firms Within the CAP Clusters,' and Table 5.6 'Employment Change and Regional Industry Share.'

economies in the periphery regions, a fact that is substantiated by the significant increase – at the 1% level – in average gross investment per firm (*K/n*).

The convergence in the number of firms (*n*) between the adjacent and periphery regions is explained by the relatively larger decline of establishments in the adjacent than that in the periphery regions. The respective changes[82] in the number of firms are 14,764 and 11,878. This resulted in a relatively larger out migration of labour from the periphery regions. Average wage per employee (*w/L*) and average wage costs per firm (*w/n*) indicate significant convergence with the adjacent regions. With the exception of Asturias, the absolute level of average wages per employee remained relatively lower creating a wage cost differential in favour of the periphery regions (Venables, 1994).

Second, the contiguity coefficient on the population variable (*P*) reveals a marginal convergence with the adjacent regions in 1997. It must be noted that the periphery regions collectively have a relatively higher total population level than all of the adjacent regions combined, and their size is comparable to that of the core regions. This fact contradicts the theory of relatively low population levels in the periphery regions vis-à-vis the core regions (Krugman, 1991b). To explain this phenomenon, we must shift our gaze to the regional classification scheme. It reflects the large number of urban areas in periphery regions with population densities between 100 but less than 500 people per square kilometre. An example would be Andalucia with nine urban areas of such size.

Third, although the data values capture the idea that periphery regions showed a relatively higher population level, the adjacent regions have a relatively higher total number of manufacturing employees. This fact is reflected in the respective labour to population ratios (*L/P*) of 7.8 and 4.4. The ratio indicates a marginal divergence in value from 1989, due to the relatively large labour outflow from the periphery regions. Population migration from the periphery exceeded that of the adjacent regions, but was less than the out-migration from the core regions. However, labour migration from the periphery was significantly larger than its population migration. This development suggests labour preference for current living conditions and their willingness to trade-off between commuting to work in the adjacent regions in lieu of abandoning local life style in the periphery regions (Ludema and Wooton, 1997).[83]

6.2.5 Conclusions of the Contiguity Analysis of the CAP Clusters

The objective of section 6.4 was to examine the 'black-box' of economic geography and assess the convergence or divergence of the economic, demographic, and manufacturing variables, within the CAP clusters, as a consequence of trade liberalisation (a reduction in τ). To this end, spatial correlation analysis was utilised to estimate the contiguity coefficients and to evaluate change in a variable value between the region types. The analysis is informative, since it provides insights into the effects of trade

[82] See Table 5A.3.

liberalisation on the regional economic development of a small economy. Specifically, it illuminates the manner in which firms and manufacturing employment responded to greater competition, and how wages, salaries, the cost of production, and gross investment were affected within the regions. A number of conclusions can be drawn.

First, as proponents of the new geography theory of trade predict, the core regions in Spain exert a strong attraction force. The core regions, by definition, have the highest population density and attracted the largest number of firms. The increased manufacturing base in the core brought with it relatively more manufacturing labour, which resulted in relatively higher wage and salary disbursements, as well as an absolute higher level of gross investment in manufacturing to achieve economies of scale. These outcomes are salient, since they substantiate the existence of agglomeration forces in the new economic geography trade theory (Krugman, 1991b; Krugman and Venables, 1996).

Second, the forces of economic integration had their most significant effect on the structural adjustment in the adjacent regions – the first concentric circle of regions. Specifically, the adjacent regions experienced a relatively larger readjustment in the number of firms versus the core region than did the periphery regions. The data reveals a reversal in the total number of firms between the core and adjacent regions. The adjacent regions experienced a net loss of firms through relocation to the core. Forslid *et al.*, (1999) found that the firms that did relocate to the core were those in need of input-output structures, facing high demand elasticities, and that were in need of high levels of economies of scale. These initial findings have subsequently been verified by the empirical work of Davis and Weinstein (1998; 1999), Henrekson *et. al.*, (1996) and Midelfart *et. al.*, (2000). Venable and Limao (2002) have argued that industries with high transport intensive commodities will also locate in or close to the core because of their production specialisation.

Third, although the core regions in the CAP model act as attraction regions, stimulating the cumulative process of agglomeration, this process spilled over into the adjacent regions, through the competition effect, as confirmed by the strong convergence of the microeconomic variables. Industries in the adjacent regions experienced a relatively higher rate of change in the average number of employees per firm, average wage per employee, and average gross investment per firm. The relatively larger change in average wages and salaries per employee in the adjacent regions suggests a relatively higher demand for labour in these regions. The higher relative average gross investment per firm suggests an expansion of plant capacity to achieve economies of scale in production and/or expand forward and backward linkages (Krugman and Venables, 1996). The absolute level of average wage per employee remained below those in the core region.

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[83] The authors assume perfect international mobility of labour. They argue labour is internationally imperfectly mobile because of their utility preference for living conditions. In this case, the negative commuting utility is outweighed by the positive utility received from local living conditions.

Fourth, these outcomes have captured a strong competition effect. This competition effect resulted in the convergence of economic variables between the core and periphery regions. Manufacturing in the periphery regions experienced a significant relatively higher rate of growth in: average gross investment per firm (*K/n*), average number of employees per firm (*L/n*), and average wage costs per firm (*w/n*). The relatively higher rate of growth in average gross investment per firm indicates an expansion of plant and capacity to attain economies of scale in production (Krugman, 1979). The strong convergence with the core, in average number of employees per firm points to a greater similarity in the production processes. The relatively higher growth rate of average wage costs per firm indicates a relocation of industries to the periphery relying on skilled labour inputs (Forslid *et al.*, 1999; Venables, 2000; Midelfart *et.al.*, 2002). These developments are most pronounced in the periphery regions – Galicia and Asturias – belonging to the CAP cluster Pias Vasco.

The data has shown how the competition effect has stimulated the development of an economic district by growing and existing industry base, starting from low initial levels, in the regions surrounding the core (Krugman and Venables, 1996). Fifth, the industry index analysis of the CAP clusters illuminated the manner in which both agglomeration and dispersion forces modify the industry structure between contiguous regions. In the CAP cluster of Cataluna, the agglomeration effect was most robust. This is manifested by the creation of a divergent production structure in relation to Cataluna's adjacent regions. For example, spatial correlation analysis captured an increase in the contiguity coefficient between the core and adjacent regions with respect to the variable gross investment (*K*). The source of this change is found in the size of the change in gross investment in Cataluna, which exceeded that of its adjacent regions, as well as the other core regions. This development substantiates Krugman and Venables' (1996) earlier conclusion pertaining to modifications in industry structures, through industry specialisation, in the core region of Cataluna. The data reveal a significant entry of new firms in the Extraction and Processing, Engineering, and Other manufacturing sectors in this agglomerate (See Table 5.6).

In contrast, the CAP clusters of Pias Vasco indicated a strong convergence of industry structure with its adjacent regions. In Pias Vasco trade liberalisation resulted in a reduction in the number of firms, and an out-migration of population and manufacturing labour. A similar trend, but of greater magnitude, was evident in its adjacent regions. The initial reduction in the supply of manufacturing employees and the need for skilled labour in export oriented firms (Forslid *et.al.*, 1999; Midelfart *et.al.*, 2000), raised the average wage per employee to such an extent that, by 1997, not only had the average wage per employee converged between all the regions in the cluster, but they had also become the highest in Spain. Developments in this CAP cluster strongly support the home market economic geography effects found by Davis and Weinstein (1999).The strong convergence of interregional industry structures and high average wages, in this cluster, suggests production specialisation in transport intensive products (Venables and Limao, 2002).

In the CAP cluster Pias Vasco, the foreign border periphery region of Galicia saw its labour force increase with total and average wages per employee rising more than in the core region. Furthermore, the average number of employees per firm, and gross investment per employee were also relatively higher than in the core region. These developments in Galicia illustrate the forces of cumulative causation generated by the competition effect in a domestic border periphery region adjacent to a foreign core region. The outcome captures the impact that trade liberalisation has had on Galicia, which has, as a result of trade liberalisation, evolved into an attractive adjacent region for industry relocation. This is particularly relevant for those industries wishing to retain their national identity and now find themselves in the position to establish demand and supply linkages with a foreign core region (Krugman and Venables, 1996).

In the CAP cluster of Madrid, industry structures converged completely between the core region of Madrid and its two adjacent regions. Agglomeration forces in the core region of Madrid led to an inflow of firms and manufacturing labour in response to higher nominal wages and salaries (Krugman, 1991b). In contrast to this, the adjacent region of Castilla Leon saw an outflow of labour, while Castilla La-Mancha experienced an increase. In both Castilla Leon and Castilla La Mancha, the total number of firms was reduced. However, there was a convergence in the microeconomic variables, caused by the relatively larger increases in the adjacent regions off; average number of employees per firm (*L/n*), average wage per employee (*w/L*), gross investment per firm (*K/n*), gross investment per employee (*K/L*), and average wage costs per firm (*w/n*). Once again, these developments reflect manufacturing's goal of achieving economies of scale in production. In absolute terms, the rates of change and the levels of these variables exceeded those in the core region.

6.3 A Spanish CAP Analysis Including Contiguous Foreign Border Regions

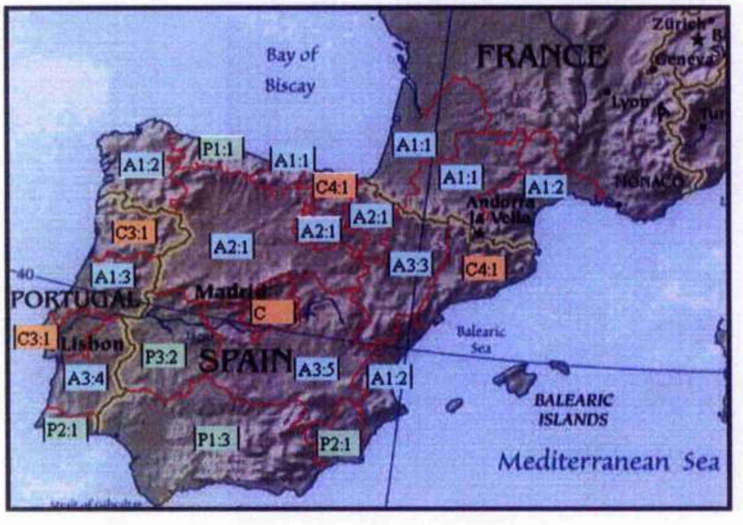
This section examines the effects of trade liberalization on the economic interaction between the Spanish, French, and Portuguese contiguous border regions. Krugman and Venables (1996) have noted that:

> *'Barriers to trade between national economies – both formal barriers such as tariffs and the de facto barriers created by differences in language and culture, lack of factor mobility, and the sheer nuisance presented by the existence of a border – are often enough to block the expansion of a successful industrial district beyond its national market.'*

The objective is to study the extent to which industry structures and economic variables, in these border regions, have converged or diverged. The analysis of the CAP-model in a closed Spanish economic system has two major drawbacks. First, it cannot be assumed that there has been an absence of trade or economic activity between Spain, its border-regions, and their foreign neighbouring regions in 1989. Second, neither can it be assumed that the Spanish data for 1997 does not include the effects of trade barrier reductions with its immediate neighbouring regions.

To examine these issues, the original industry index and contiguity analysis have been modified to include Portuguese and French border regions. The Portuguese regions are: the core region of Norte, the adjacent regions of Centro and Alentejo, and the periphery region of Algarve. The French regions consist of *ex ante* periphery regions: Aquitaine, Languedoc Roussillon, and Midi-Pyrenees. These border regions are shown in Map 2.

MAP 2
SPANISH FOREIGN BORDER REGIONS: FRANCE AND PORTUGAL



In the Spanish west, the Portuguese (P) core region of Norte borders on the Spanish regions of Galicia, and Castilla Leon; the adjacent region of Centro in Portugal borders on the Spanish regions of Castilla Leon and Extremadura; while, the adjacent Portuguese region of Alentejo borders on Extremadura and Andalucia; and, finally, the periphery region of Andalucia borders on the Portuguese periphery region of Algarve.

In the Spanish north, the French region of Aquitaine borders on the Spanish core region of Pias Vasco, and the adjacent regions of Navarra and Aragon; The French region of Midi-Pyrenees borders on the adjacent region of Aragon, and the core region of Cataluna; while, finally, the French region of Languedoc Roussillon borders entirely on the core region of Cataluna.

6.3.1 Industry Index Bordering Regions

The industry index outcomes for the bordering regions are presented in Table 6.2.The contiguous border regions are grouped into region types in column (2) of Table 6.2. Their industry index values for 1989 and 1997 are respectively listed in columns (3) and (4). The mutations in industry structures between the contiguous regions are listed in column (5).

In general, it is evident that the industry structures between Spain and Portugal converged, while those between Spain and France diverged. More specifically, the strongest convergence occurred between the core region of Norte in Portugal and Galicia in Spain. This change exceeded all of the convergence values between Galicia and its accompanying regions in the CAP cluster of Pias Vasco. This development can be explained by Galicia's relative proximity to Norte versus Pias Vasco (Krugman and Venables, 1996).

TABLE 6.2
INDUSTRY INDEX VALUES FOR SPANISH AND FOREIGN BORDER REGIONS

(1)	(2)	(3)	(4)	(5)
COUNTRIES	BORDER REGIONS	Index value 1989	Index Value 1997	Index Value Changes[1]
	CORE – ADJACENT			
Spain / Portugal	Norte – Galicia	1.610	0.935	0.675
	Norte – Castilla Leon	1.154	1.053	0.101
Spain – France	Pias Vasco – Aquitaine	0.833	0.842	-0.009
	Cataluna – Midi-Pyrenees	0.516	0.610	-0.093
	Cataluna – Languedoc Roussillon	0.616	0.636	-0.020
	CORE – PERIPHERY			
Spain – Portugal	Norte – Asturias	1.470	1.204	0.196
	Norte – Extremadura	1.074	0.927	0.147
	ADJACENT - PERIPHERY			
Spain – France	Navarra – Aquitaine	0.698	0.682	0.016
	Aragon – Midi Pyrenees	0.619	0.687	-0.068
Spain – Portugal	Centro – Extremadura	1.004	0.640	0.364
	Centro – Castilla Leon	0.997	0.770	0.227
	Alentejo – Extremadura	0.800	0.498	0.302
	Alentejo – Andalucia	0.573	0.419	0.154
	Algarve – Andalucia	0.746	0.621	0.125

1. Positive value = Convergence. Negative value = Divergence
Source: Author's own calculations.

The other significant development of trade liberalisation is the increased convergence between the Portuguese adjacent regions of Centro and Alentejo and the Spanish periphery regions of Extremadura and Andalucia. Specifically, Extremadura has evolved to become more similar to the adjacent region of Centro, than to its core region of Madrid,[84] which demonstrated a divergence in index values. Of greater significance is the fact that Extremadura has shown the strongest convergence in industry structure with the Portuguese adjacent region of Alentejo. The Spanish periphery region of Andalucia and the Portuguese adjacent region of Alentejo, where the same strong convergence has occurred in the industry structures, parallel this development. Both of these Spanish regions have diverged strongly, in industry structure, with regions in their own Spanish CAP clusters. These outcomes suggest the development of interregional economic manufacturing linkages (Krugman and Venables, 1996; Venables and Limao, 1999).

The border regions of France experienced a marginal divergence from their Spanish counterparts in industry structure. A salient point is that prior to 1989, the industry structures of the Spanish and French border regions paralleled each other to a greater degree. This similarity was more pronounced than between the Portuguese and Spanish border regions (with the exception Alentejo/Extremadura

[84] See Table 5.3.d for these comparisons.

/Andalucia). Although the outcomes revealed that the core region of Cataluna diverged marginally from the two French regions of Midi-Pyrenees and Languedoc Roussillon, this Spanish core region maintained a stronger similarity to the French regions *ex post*, than it did to the regions in its own CAP cluster.

This section can be concluded with the following observations. First, Spain joined the EU customs union in 1986, and by 1989, its industry structure more closely resembled that of the of the French border regions, than of the Portuguese border regions. This implies the existence of economic ties with France before Spain joined the EU. Second, by 1989, there also appears to have been some similarity between the Spanish southern periphery regions and the Portuguese adjacent regions. EU 1992 amplified these similarities to a significant degree. In fact, the Spanish periphery regions converged more with the Portuguese adjacent regions, than with their own Spanish adjacent regions. This explains the divergence of industry structures between these periphery regions and the regions in the Madrid CAP cluster as found in Section 5.3.1.2. A possible explanation for this development the Spanish and Portuguese border regions is the combination of comparable regional geographic location, commodity transport intensity, and factor intensity in comparison to existing economic activities in Portugal (Venables and Limao, 2002)

Third, in general, trade liberalization had a greater relative convergence effect on the Spanish border regions than on the French border regions. A possible explanation for this development is geographic proximity and Portuguese/Spanish cultural affinity, exemplified through labour's location preference in periphery regions (Ludema and Wooton, 1997).

6.3.2 Spatial Correlation Analysis Including Spanish Foreign Border Regions

The objective of this section is to analyse the effects of agglomeration and dispersion forces on the economic development of the border regions. The spatial correlation analysis now includes the Portuguese (P) and French (F) border regions in the respective k – connections, and is calculated in the identical manner as in Section 6.4. The core adjacent connections now include Norte (P), Centro (P), Aquitaine (F), Midi Pyrenees (F), and Languedoc Roussillon (F). The adjacent periphery regions include: Centro (P), Alentejo (P), and Algarve (P).

In Table 6.3, below, the original contiguity values for the closed economy (CE) are presented for comparison with the new calculations of the open economy (OE) listed in Table 6.4. In the following section, we highlight the most salient developments.

First, the contiguity coefficients for the closed economy in 1989 indicate a different pattern than that for the open economy case. In the former (CE), the first-order contiguity values of the 8^{th} through the 12^{th} variables, in 1989, are all negative. Conversely, in the latter (OE), the same variables report positive values. In general, this outcome suggests a stronger convergence between the core and adjacent regions in the (OE) model in 1989, than in (CE) model for the same year. The opposite is true for the second-order contiguity coefficients in 1989, where there appears to be a strong negative relationship between the core and periphery regions.

Second, in 1997, the first-order coefficients on the 8th through 12th variables show convergence, with the exception of the variable (10th) average gross investment per employee (*K/L*). The same second-order coefficients reveal a much larger magnitude of convergence, with the exception of average wage per employee (11th), than do the first order coefficients. This indicates a strong convergence between the core and periphery regions in the open economy case.

TABLE 6.3
SPATIAL CORRELATION COEFFICIENTS FOR THE CAP REGIONS IN SPAIN

		CONTIGUITY ORDER: k = 1,2					
		1		2		1	
		CORE-ADJACENT		*CORE-PERIPHERY*		*ADJACENT-PERIPHERY*	
	VARIABLES	*1989*	*1997*	*1989*	*1997*	*1989*	*1997*
1	Per Capita Income (Y / C)	1.37	1.35	1.71	1.75	0.61	0.83
2	Population (P)	0.85	0.84	1.21	0.77	0.64	0.63
3	Number of Firms (n)	0.58	0.67	0.93	0.77	0.79	0.59
4	Number of Manufacturing Employees (L)	0.99	0.92	1.08	0.96	0.79	0.69
5	Manufacturing Employees / Population (L / P)	0.39	0.50	0.47	0.81	0.63	0.64
6	Wages and Salaries (w)	1.29	1.16	1.17	1.06	0.92	0.83
7	Gross Investment (K)	1.05	1.13	0.39	0.91	0.79	0.83
8	Average Number of Employees per Firm (L / n)	2.04	0.28	0.97	0.35	0.61	0.16
9	Average Gross Investment per Firm (K / n)	1.95	0.35	0.98	0.21	1.06	0.26
10	Average Gross Investment per Employee (K / L)	1.46	0.63	0.56	0.59	1.08	1.44
11	Average Wage per Employee (w / L)	1.54	0.62	1.29	0.93	0.49	0.39
12	Average Wage Costs per Firm (w / n)	2.09	0.31	1.05	0.36	0.56	0.34

Source: Authors own calculations / Contiguity Analysis / Excluding the Island Regions

TABLE 6.4
SPATIAL CORRELATION COEFFICIENTS FOR THE SPANISH AND FOREIGN BORDERING CAP REGIONS

		CONTIGUITY ORDER: k = 1,2					
		1		2		1	
		CORE-ADJACENT		*CORE-PERIPHERY*		*ADJACENT-PERIPHERY*	
	VARIABLES	*1989*	*1997*	*1989*	*1997*	*1989*	*1997*
1	Per Capita Income (Y / C)	0.39	0.86	1.10	1.31	0.44	0.99
2	Population (P)	1.34	1.30	0.81	0.81	1.19	1.18
3	Number of Firms (n)	1.41	1.54	0.71	1.49	0.84	0.83
4	Number of Manufacturing Employees (L)	1.98	1.92	1.21	1.49	0.94	0.90
5	Manufacturing Employees / Population (L / P)	0.70	1.30	0.61	1.39	0.61	1.03
6	Wages and Salaries (w)	2.05	2.03	1.04	1.09	1.01	0.95
7	Gross Investment (K)	1.54	1.77	1.02	1.15	0.90	1.02
8	Average Number of Employees per Firm (L / n)	0.94	0.50	1.43	0.49	0.80	0.25
9	Average Gross Investment per Firm (K / n)	0.75	0.71	1.46	0.80	1.41	0.50
10	Average Gross Investment per Employee (K / L)	0.58	0.84	1.28	0.88	0.62	0.23
11	Average Wage per Employee (w / L)	0.61	0.48	1.08	1.03	0.41	0.32
12	Average Wage Costs per Firm (w / n)	0.74	0.45	1.40	0.70	0.18	0.05

Source: Authors own calculations / Contiguity Analysis / Excluding the Island Regions

Third, the second-order contiguity coefficients, variables 1 through 7, exhibit a strong divergence in the (OE) case. This divergent pattern between 1989 and 1997 is at variance with the closed economy case. The reason for this must be found in developments in the periphery regions.

Fourth, the first-order contiguity values for the adjacent periphery regions, variables 8 through 12, illustrate a very strong convergence in the open economy model in 1997. On average their values are more robust than in the closed economy case.

A General Analysis of the Variables in the Border Regions[85]

In 1997, the per capita income (*Y/P*) variable captures a divergence in value between all regions. This divergence in 1997 is caused by the significant per capita income increases in the Portuguese border regions, and the declining per capita income levels in the French border regions. The average decline in the French regions was 11.2%, while the Portuguese regions showed 22.9 % increase. In comparison, the average per capita income increase in the Spanish border regions was about 5.1%

The population variable (*P*) indicates a constant positive relation for the core and periphery regions between 1989 and 1997. This reflects the population inflow into the Spanish periphery regions of Murcia and Andalucia, as well as into the three French border periphery regions. Similarly, the Portuguese core region of Norte experienced a population increase.[86]

The variable, number of firms (*n*), shows a divergent trend between the core and adjacent, and the core and periphery regions. This divergence is caused by the significant increases in the number of firms in the Portuguese core (39,096) and adjacent regions (17,970), as well as the large increases in the French border periphery regions (36,674). The Portuguese periphery region of Algarve also experience industry growth. In contrast, only the Spanish core regions of Cataluna and Madrid observed an increase of their industry base, while the Spanish foreign border regions all witnessed a decline! The reasons for this decline in the Spanish regions is twofold: one, a relocation of industry and manufacturing labour, which appears to be the case in Pias Vasco, Navarra, Aragon, Castilla Leon, Extremadura, and Andalucia; two, the merger of firms, which appears to be the case in Galicia, since it experienced an inflow of manufacturing labour.[87]

The negative contiguity coefficient on the 4th variable, number of manufacturing employees (*L*) is the result of the labour inflow with the newly established firms in the border periphery regions of Portugal and France. The increases were respectively: in Portugal, the core region of Norte (264,307); the adjacent regions of Centro and Alentejo (70,818); in France, the periphery regions of Aquitaine, Midi-Pyrenees, and Languedoc Roussillon (36,674). The labour inflows into the foreign border regions resulted in a sharp divergence of the ratio, manufacturing employees to population (*L/P*), between 1989 and 1997. The most significant increases occurred in the Portuguese and French regions, while declines were evident in most of Spanish adjacent and periphery regions.

The significant increase in the number of manufacturing employees in the Portuguese and French border regions resulted in relatively higher level of wage and salary disbursements (*w*) than the Spanish regions. As a result, the contiguity coefficients between the region pairs remained negative. The marginal convergence of this variable between the adjacent and periphery regions is due to the relatively higher wage and salary levels in the French periphery regions.

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85 See, Chapter 6, Appendix 6C, Table 6C.3, for the actual regional data used in the analysis.
86 This study does not examine the issue of international migration. We assume population increases in regions are the result of domestic internal interregional migration.

The 7[th] contiguity variable, gross investment (K), also indicates a divergence in value between the k region pairs[88]. The change in gross investment in the core region of Norte exceeded that of its adjacent regions by a factor of 1.6. Combined, the values for the three French periphery regions revealed a change in their levels of gross investment that was comparable to the change in the core region of Norte, and that of Cataluna in Spain. On average, the change in the level of gross investment in the respective three French regions was comparable to that of the Spanish periphery region of Galicia. The three periphery French regions border on two Spanish core regions, while the periphery region of Galicia borders on the core region of Norte. This is a significant outcome, since it reveals the need by industries, in the former periphery regions, to acquire economies of scale in production. It is again evidence of the strength of the competition effect to achieve profitability in production (Baldwin *et al.*, 2002).

The 8[th] variable indicates a strong convergence in the average number of manufacturing employees per firm (L/n). This strength of this convergence is derived from the significant declines in this ratio in the Portuguese regions of Norte, Centro, Alentejo, and Algarve. The French regions also exhibit a significant reduction in this ratio. In the open economy case, the average value of this ratio has shown a strong convergence between all region types. It is interesting to note that the French regions reveal values for this ratio that lie below the average for all the periphery regions. The overall development of the contiguity values of the ratio, average number of manufacturing employees per firm, reflects an increased similarity in production structures among the regions, especially between the core and adjacent regions.

There was also a significant convergence of average gross investment per firm (K/n) between the k - region pairs. For instance, significant declines occurred in all of the French and Portuguese regions to bring them in line with their Spanish counterparts. In 1997, the average value of this ratio was highest in the adjacent regions (€ 108.500), followed by the periphery (€ 95.600) and the core (€ 94.500) regions. In general, industries in the Spanish adjacent regions experienced the largest increase in this ratio, indicating a 'catch-up' effect with the core regions.

The 10[th] variable, gross investment per employee (K/L), indicates a strong positive relationship between the core and adjacent regions in 1989, but a negative value between the core and periphery regions. The average value for this variable was the same for the core (€3,400) and for the adjacent (€3,400) regions in 1989, but diverged with the periphery (€5,300) regions. In 1997, the first-order contiguity coefficient reveals a positive diverging value that reflects the significantly high level of gross investment per employee in the Portuguese adjacent region of Alentejo. The significant convergence of variable value between the core and periphery is due to a relatively higher rate of change in the periphery regions. This is best exemplified in the Spanish region of Murcia. The relatively high levels of gross investment in the adjacent region of Alentejo, and the periphery region of Murcia, led to the strong convergence in this variable between adjacent and periphery regions. Gross investment per employee

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[87] A third possibility would be the wholesale death of firms with labour migrating to other regions.

was, on average, higher in the periphery regions than in the adjacent regions. This, again, supports the earlier findings of high investment levels to attain economies of scale in production to offset a geographic location disadvantage.

The 11th variable, average wage per employee (*w/L*), exhibits a positive value between the core and adjacent regions, but a negative value between the core and periphery regions. In 1989, the average wage per employee was higher in the core than in the adjacent regions, but lower than in the periphery regions. This higher average value in the periphery regions signals the high average wage per employee in the French periphery regions, in which the average wage per employee exceeded that of the Spanish core regions. In contrast, the average wage per employee in the Portuguese regions was absolutely lower than in Span.

In 1997, the French regions continued to enjoy a higher average wage per employee (€22,178), than displayed in any of the Spanish or Portuguese regions. The average rate of change in the French regions (€5,008) was comparable to the rate of change in the Spanish core regions of Pias Vasco (€4,102) and Cataluna (€4,013), but remained below that of the adjacent region of Navarra (€9,016) on which they border. The adjacent region of Navarra has the highest level of average wage per employee (€21,957) in Spain. This convergence of average wage per employee in these adjoining border regions is evidence of Stolper-Samuelson factor-price equalisation.

In contrast, the Portuguese average wage per employee in the core region of Norte is about one-third that of the Spanish core regions (€6,363). In the Portuguese adjacent regions the average wage per employee is approximately one-half of that of its contiguous Spanish border regions (€7,262). There is no convergence of average wage per employee between the Spanish and Portuguese border regions. The Portuguese border regions, whether core or adjacent, have an absolute lower level of average wage per employee. The convergence of wages between the adjacent and periphery regions, as revealed by the contiguity coefficient, consists entirely of convergence between the French and Spanish border regions in the north.

Finally, average wage costs per firm (*w/n*) converged strongly between the core and adjacent regions. This result highlights the competition effect at work in the adjacent regions versus the core regions. In Portugal, average wage costs declined significantly in the core and adjacent regions and remained absolutely lower than in any of the Spanish or French regions. The formidable convergence in wage costs between the core and periphery regions is the direct result of significant wage cost declines in the French border regions, to equate with levels in the Spanish border regions. The reduction in average wage costs in both the French and Portuguese regions resulted in the strong convergence between the adjacent and periphery regions.

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[88] This refers to the contiguity order between the regions being measured.

6.3.3 Conclusion on Border Regions

What have we learned from the border region analysis with respects to the effects of trade liberalisation? The objective of the analysis in this section was to examine the effects of agglomeration and dispersion forces on the economic geography of these regions. The analysis has revealed two sets of results; the first of these pertains to industry structures, and the second, concerns economic growth in the border regions.

First, the development of industry structures in the two sets of Spanish border regions contiguous to Portugal and France is unequal. However, a strong convergence in industry structures occurred between the Portuguese and Spanish border periphery regions. The most significant of which was found in the Spanish periphery region of Galicia. The changing composition of industry structure in the periphery regions of Extremadura and Andalucia resulted in a stronger convergence with the Portuguese border regions than with the regions in their own CAP cluster of Madrid.

The reasons for this convergence could possibly be explained by; i) geographic proximity to the densely populated Portuguese core regions of Norte and Lisboan, ii) the freedom to develop interregional and intersectoral linkages, and iii) the need to exploit comparative advantage (Ludema and Wooton, 1997; Forslid *et al.* 1999; Venables and Limao, 2002). The industry structure in Andalucia became more similar to that of Galicia (see Table 5.2). This finding is informative since it points to the duplication in production structures in Spain, possibly to meet export demand. The average wage per employee is almost identical in these two periphery regions, which suggests the possibility of resource intensive production and products. In general, it possible to conclude that the similarity in industry structures between the French and Spanish border regions remained unaltered subsequent to economic integration. This invariability suggests that industry structures had converged before 1989. It also points to the existence of interregional and intersectoral economic linkages between French periphery regions and Spanish core and adjacent regions.

Second, both agglomeration and dispersion forces endogenously changed the economic variables in the border regions. Agglomeration forces resulted in the pronounced increases in the number of firms (n), manufacturing labour (L), and wages (w) in the core regions. The competition effect manifested itself strongly in the *ex ante* border periphery regions contiguous to foreign core and adjacent regions. In the *ex post* period, these reclassified adjacent regions experienced strong inflows of: population, labour, and firms. These factors combined to raise total wages and salaries. In these regions, average wages per employee converged strongly with their contiguous core and adjacent regions. Given the imperfect mobility of labour between these foreign bordering regions, average wage convergence implies factor-price equalisation through trade.

The competition effect in the border regions resulted in relatively high levels of gross investment that converged with levels in the Spanish and Portuguese core regions. The convergence of the average number of employees per firm ratio between the core and adjacent regions, combined with the convergence of average wage costs per firm, implies the attainment of cost minimising production structures in the Spanish, and the *ex post* adjacent regions. A relatively lower average number of employees per firm ratio, and a relatively higher level of average gross investment per employee, offset the relatively higher average wage in the French regions. This finding implies French industry is relatively more capital intensive.

Finally, although the competition effect is evident in the Spanish border periphery regions of Extremadura and Andalucia, causing industry structure to convergence with the Portuguese adjacent regions, there is no convergence of average wages between these border regions. In absolute terms, Portuguese border region wages remain significantly lower than Spanish border region wages. The existing wage differential between these region types, illustrates that Portugal, is geographically, relatively more peripheral than Spain.

2 THE SPATIAL CORRELATION COEFFICIENT

The spatial correlation is defined by the following statistic;

$$c_k = \frac{\sum_{r=1}^{R}\sum_{i_{kr}}^{I_{kr}} (x_r - x_{i_{kr}})^2}{2I_k} \bullet \frac{R-1}{\sum_{r=1}^{R}(x_r - \overline{x})^2} \tag{6A.1}$$

Where x is the value of a demographic or economic variable in region r ($r = 1,\ldots, R$). The subscript i_{kr} ($i_{kr} = 1_{kr}, 2_{kr} \ldots I_{kr}$) refers to each region i_{kr}, which possesses a k^{th} order contiguity with respect to region r. Thus, the total number of k^{th} connections for region r is equal to I_{kr}, while I_k is defined as the total number of connections of order k within the whole system, that is;

$$I_k = \sum_{r=1}^{R} I_{kr} \tag{6A.2}$$

Finally, $\overline{x}$ is defined as the national average of the demographic or economic variable under consideration, such that;

$$\overline{x} = \sum_{r=1}^{R} \frac{x_r}{R} \tag{6A.3}$$

The first element on the right hand side of equation (6A.1) is the statistical contiguity variance. The numerator of this element is a measure of the aggregated squared differences of a variable between a central region and its surrounding regions, calculated over all the regions. The value of the denominator measures the total number of k - order connections i.e. I_k. In the denominator, the factor 2 is used to assure that the value of the spatial correlation coefficient of being equal to unity in case there is no spatial correlation of order k.

The second element on the right hand side of equation (6A.1) is the inverse of the variance of the particular variable under consideration. It measures the aggregated squared differences between each observation in the variable and its national average.

As noted above, the statistic c_k is a measure that indicates the strength of the spatial correlation of an economic variable between regions. If $c_k = 1$, there is no spatial correlation; if $c_k < 1$, there is a positive spatial correlation, and if $c_k > 1$, there is a negative spatial correlation. The compliment of the spatial correlation coefficient is given by the coefficient δ_k, which is defined as:

$\delta_k = 1 - c_k$ (6A.4)

Where δ_k is the *coefficient of spatial influence*. If, $\delta_k = 0$, there is no spatial correlation; if $\delta_k > 0$ a positive spatial correlation is present, and if $\delta_k < 0$, the spatial correlation effect is negative.

The statistical value of the spatial correlation coefficient varies with the value of k. For a first-order contiguity, $k = 1$, the spatial correlation coefficient c_k or the coefficient of spatial influence, δ_k, calculates the direct spatial correlation of the first ring of adjacent (contiguous) regions. For a second-order contiguity, $k = 2$, the indirect influence of the first on the third region is measured.

Some Properties of the Spatial Correlation Coefficient[89]

Define the first factor of (6A.1), the contiguity variance as F_1, then expand and rearrange terms:

$$F_1 = \frac{\sum_{r=1}^{R}\sum_{i_{kr}=1_{kr}}^{I_{kr}} (x_r - x_{i_{kr}})^2}{2I_k} = \frac{\sum_{r=1}^{R}\sum_{i_{kr}=1_{kr}}^{I_{kr}} (x_r^2 - 2x_r x_{i_{kr}} + x_{i_{kr}}^2)}{2I_k}$$

$$F_1 = \frac{\sum_{r=1}^{R} I_{kr} x_r^2 - 2\sum_{r=1}^{R}\sum_{i_{kr}=1_{kr}}^{I_{kr}} x_r x_{i_{kr}} + \sum_{r=1}^{R}\sum_{i_{kr}=1_{kr}}^{I_{kr}} x_{i_{kr}}^2}{2I_k}$$

$$F_1 = \frac{\sum_{r=1}^{R} I_{kr} x_r^2}{2I_k} - \frac{\sum_{r=1}^{R}\sum_{i_{kr}=1_{kr}}^{I_{kr}} x_r x_{i_{kr}}}{I_k} + \frac{\sum_{r=1}^{R}\sum_{i_{kr}=1_{kr}}^{I_{kr}} x_{i_{kr}}^2}{2I_k} \quad (6A.5)$$

Next, assume that all regions r ($r = 1, \ldots, R$) have an equal number of connections of a certain order k (as in the case of a regular regional pattern). This will imply that I_{kr} is constant for each region r, that is,

$$I_k = I_k^* \quad (6A.6)$$

The system is said to be homogenous of order k. It should be noted, that (6A.6) does not imply that the number of connections of region r over all contiguity orders k is constant. Since each region r possesses

$$I_k = RI_k^* \quad (6A.7)$$

[89] Paelinck and Nijkamp, (1975)

Substitution of (6A.6) and (6a.7) into the first term of (6A.5) yields:

$$\frac{\sum_{r=1}^{R} I_{kr} x_r^*}{2I_k} = \frac{\sum_{r=1}^{R} I_k^* x_r^2}{2RI_k^*} = \frac{\sum_{r=1}^{R} x_r^*}{2R} \tag{6A.8}$$

In a similar way equation (6A.6) and equation (6A.7) can be substituted into the third term of equation (6A.5) to obtain:

$$\frac{\sum_{r=1}^{R} \sum_{i_{kr}=1_{kr}}^{I_{kr}} x_{i_{kr}}^2}{2I_k} = \frac{\sum_{r=1}^{R} I_k^* x_r^2}{2RI_k^*} = \frac{\sum_{r=1}^{R} x_r^2}{2R} \tag{6A.9}$$

The operation in equation (6A.9), in which the terms $x_{i_{kr}}^2$ are transformed into x_r^2, is justified, because each term $x_{i_{kr}}^2$ in the summation is added I_k^* times. The implication is that the first and third terms of equation (6A.5) are exactly equal. Finally, the second term can be rewritten as:

$$\frac{\sum_{r=1}^{R} \sum_{i_{kr}=1_{kr}}^{I_{kr}} x_r x_{i_{kr}}}{I_k} = \frac{\sum_{r=1}^{R} \sum_{i_{kr}=1_{kr}} x_r x_{i_{kr}}}{RI_k^*} = \frac{\sum_{r=1}^{R} \sum_{i_{kr}=1_{kr}}^{I_k^*} (x_r - \bar{x})(x_{i_{kr}} - \bar{x}) + RI_k^* \bar{x}^2}{RI_k^*} \tag{6A.10}$$

Where, $\bar{x}$ is defined in equation (6A.3). The latter operation is permitted, because

$$\sum_{r=1}^{R} \sum_{i_{kr}=1_{kr}}^{I_k^*} (x_r - \bar{x})(x_{i_{kr}} - \bar{x}) = \sum_{r=1}^{R} \sum_{i_{kr}=1_{kr}}^{I_k^*} (x_r x_{i_{kr}} - \bar{x} x_r - \bar{x} x_{i_{kr}} + \bar{x})^2$$

Multiplying and expanding:

$$\sum_{r=1}^{R} \sum_{i_{kr}=1_{kr}}^{I_k^*} x_r x_{i_{kr}} - \bar{x} I_k^* \sum_{r=1}^{R} x_r - \bar{x} \sum_{r=1}^{R} \sum_{i_{kr}=1_{kr}}^{I_k^*} x_{i_{kr}} + RI_k^* \bar{x}^2 = \sum_{r=1}^{R} \sum_{i_{kr}=1_{kr}}^{I_k^*} x_r x_{i_{kr}} - \bar{x} I_k^* (R\bar{x}) - \bar{x}(RI_k^* \bar{x}) + RI_k^* \bar{x}^2$$

$$= \sum_{r=1}^{R} \sum_{i_{kr}=1_{kr}}^{I_k^*} x_r x_{i_{kr}} - RI_k^* \bar{x}^2 \tag{6A.11}$$

Substitution of equations (6A.8), (6A.9) and (6A.10) into equation (6A.5) gives the result:

$$F_1 = \frac{\sum_{r=1}^{R} x_r^2}{R} - \frac{\sum_{r=1}^{R} \sum_{i_{kr}=1_{kr}}^{I_k^*} (x_r - \overline{x})(x_{i_{kr}} - \overline{x})}{R I_k^*} - \overline{x}^2 \tag{6A.12}$$

The second term of (6.12) represents the correlation coefficient of a regional variable with respect to the same variable in contiguous regions of order k. If there is no spatial correlation (and thus no sphere of influence of the regions), this correlation coefficient will equal zero. Then F_1 is equal to:

$$F_1 = \frac{\sum_{r=1}^{R} x_r^2 - R\overline{x}^2}{R} = \frac{\sum_{r=1}^{R} (x_r - \overline{x})^2}{R} \tag{6A.13}$$

By substituting (6A.13) into (6A.1) we find the expression for the contiguity correlation coefficient c_k in case of no spatial correlation:

$$c_k = \frac{\sum_{r=1}^{R} (x_r - \overline{x})^2}{R} \bullet \frac{R-1}{\sum_{r=1}^{R} (x_r - \overline{x})^2} = \frac{R-1}{R} \approx 1 \tag{6A.14}$$

This result supposes that R is sufficiently large. One may prove that the mathematical expectation of c_k is exactly equal to 1 if there is no spatial correlation. Therefore, we can conclude that $c_k = 1$ if there is no contiguity effect of order k. Furthermore, in the case of a positive spatial correlation, F_1 is smaller than equation (6A.13), so that a positive spatial correlation implies $c_k < 1$. In the reverse case of a negative spatial correlation, one may prove that $c_k > 1$.

CALCULATING THE SPATIAL CORRELATION COEFFICIENT

Table 6B.1 provides an overview of the number of connections between the Provinces in the Netherlands.

TABLE 6B.1
CONTINGENCY TABLE FOR THE NETHERLANDS

Provinces		Presence of *k*- order connections 1	2	3	4	5	6	7	8	9	10	11	Nr. of 1st Conn	Nr. of 2st Conn	Nr. of 3st order Conn	Nr. of 4st order Conn
Groningen	1		1	1	2	3	3	2	3	4	4	4	2	2	3	3
Friesland	2	1		1	1	2	2	1	2	3	3	3	4	3	3	0
Drenthe	3	1	1		1	2	3	2	3	4	3	3	3	2	4	1
Overijssel	4	2	1	1		1	2	2	2	3	2	2	3	6	1	0
Gelderland	5	3	2	2	1		1	2	1	2	1	1	5	4	1	0
Utrecht	6	3	2	3	2	1		1	1	2	2	2	3	5	2	0
Noord-Holland	7	2	1	2	2	2	1		1	2	2	3	3	6	1	0
Zuid-Holland	8	3	2	3	2	1	1	1		1	1	2	5	3	2	0
Zeeland	9	4	3	4	3	2	2	2	1		1	2	2	4	2	2
Noord-Brabant	10	4	3	3	2	1	2	2	1	1		1	4	3	2	1
Limburg (NL)	11	4	3	3	2	1	2	3	2	2	1		2	4	3	1
												Totals	36	42	24	8
		Total number of connections of order *k*											$Ik = 1$	$Ik = 2$	$Ik = 3$	$Ik = 4$

Source: Paelinck and Nijkamp, *Op. Cit.*, p. 231 (Table 4.7.2.b)

The eleven Dutch Provinces are listed in the left-hand column and are numbered from one to eleven. The section, 'Presence of *k*-order Connections', is a symmetric matrix. An example of a *first-order* contiguity connection is the relationship between Groningen and its adjoining Provinces of Friesland and Drenthe. The Province of Groningen has a *second-order* contiguity connection with the Province of Overijssel since it geographically belongs to the second ring of regions around the Province of Groningen. An example of a *fourth-order* contiguity connection is the relationship between the Province of Groningen and the Province of Limburg. Groningen is the most Northern Dutch Province, while Limburg is found in the south bordering on Belgium and Germany. The variable geographic *distance* (d_1, d_2, d_3 and d_4) between the Provinces is directly defined by the contiguity order k, and is implicitly assumed in the analysis.

An example of how to calculate a first-order contiguity coefficient is shown in Table 6B.2. The Dutch Provinces are listed in the left-hand column. The demographic variable to be examined is 'Number of Inhabitants per Square Kilometre' for 1960 and 1965. The respective calculations are presented in columns (1) and (2) based on the number of *first-order* connections $I_k = 1$, as shown in Table B.1. We can calculate the separate elements of equation (6.1) as follows;

TABLE 6B.2
CALCULATION OF THE CONTIGUITY COEFFICIENT

	Number of inhabitants per square kilometre		Calculations for 1960		
Netherlands	1960	1965	(1)	(2)	
1 Groningen	205	216	11492	25397	
2 Friesland	141	148	405576	49891	
3 Drenthe	119	129	11976	60203	
4 Overijssel	205	229	12168	25397	
5 Gelderland	231	253	635066	17786	
6 Utrecht	518	562	333002	23604	
7 Noord-Holland	771	811	492950	165353	
8 Zuid-Holland	950	995	1775751	342970	
9 Zeeland	160	165	645125	41764	
10 Noord-Brabant	305	336	452130	3524	
11 Limburg (NL)	403	436	22829	1493	
Average	364	389	4798065	757383	
			66639.7917	1.3203E-05	
			First-order contiguity coefficient value =		0.8799

Source: Author's own calculations of Paelinck and Nijkamp results.

STEP 1

In column (1), we first calculate the statistic between Groningen, x_r, and its two adjoining Provinces, Friesland and Drenthe, as follows:

$$(x_r - x_{i_{kr}})^2 = (205-141)^2 + (205-119)^2 = 11{,}492$$

STEP 2

Repeat step (1) for the first-order connections between Friesland and its adjoining Provinces.

$$(x_r - x_{i_{kr}})^2 = (141-205)^2 + (141-119)^2 + (141-205)^2 + (141-771)^2 = 405{,}576$$

STEP 3

Repeat the first two steps for all the Provinces following the number of first-order connections for each Province. Then take the sum of column (1), which gives:

$$\sum_{r=1}^{R} \sum_{i_{kr}}^{I_{kr}} (x_r - x_{i_{kr}})^2 = 4{,}798{,}065$$

STEP 4

In column (2), calculate the squared deviation from the mean of the original data.

$(x_1 - \overline{x})^2 = (205 - 364) = 25{,}397$

Repeat for all the observations.

STEP 5

Sum column (2) to obtain the sum of the squared errors.

$$\sum_{r-1}^{R} (x_r - \overline{x})^2 = 2{,}217{,}752$$

STEP 6

From Table B.1, take the total number of first-order connections.

$$2I_k = 2.(36) = 72$$

STEP 7

Substitute the relevant values into equation (6.1) to obtain the *first-order* contiguity coefficient for R = 11.

$$c_k = \frac{\sum_{r=1}^{R} \sum_{i_{kr}}^{I_{kr}} (x_r - x_{i_{kr}})^2}{2I_k} \bullet \frac{R-1}{\sum_{r=1}^{R} (x_r - \overline{x})^2} = \frac{(4798065\,)}{72} . \frac{10}{757383} = 0.8798$$

Since the *first-order* contiguity coefficient is less than one, $c_k = 0.8798$, we can conclude that a positive relationship exists between the movement of the variable 'Number of Inhabitants per Square Kilometre' between all the first-order connections.

TABLE 6C.1
DEFINING THE REGIONAL CONNECTIONS

	2.1 Regions	*1st – Order-Connections for Core Adjacent Regions*				I_k
1.	Galicia					
2.	Asturias					
3.	Cantabria	Pias Vasco				1
4.	Pias Vasco	Cantabria	Navarra	La Rioja	Castilla Leon	4
5.	Navarra	Pias Vasco				1
6.	La Rioja	Pias Vasco				1
7.	Aragon	Cataluna				1
8.	Madrid	Castilla Leon	Castilla La Mancha			2
9.	Castilla Leon	Madrid	Pias Vasco			2
10.	Castilla La Mancha	Madrid				1
11.	Extremadura					
12.	Cataluna	Aragon	Communidad Valencia			2
13.	Communidad Valencia	Cataluna				1
14.	Andalucia					
15.	Murcia					
					$I_k =$	16

	2.2 Regions	*2nd – Order-Connections for Core periphery Regions*				I_k
1.	Galicia	Madrid				1
2.	Asturias	Pias Vasco				1
3.	Cantabria					
4.	Pias Vasco	Asturias				1
5.	Navarra					
6.	La Rioja					
7.	Aragon					
8.	Madrid	Galicia	Extremadura	Andalucia		3
9.	Castilla Leon					
10.	Castilla La Mancha					
11.	Extremadura	Madrid				1
12.	Cataluna	Murcia				1
13.	Communidad Valencia					
14.	Andalucia	Madrid				1
15.	Murcia	Cataluna				1
					$I_k =$	10

	2.3 Regions	*1st – Order-Connections for Adjacent -Periphery Regions*				I_k
1.	Galicia	Castilla Leon				1
2.	Asturias	Castilla Leon	Cantabria			2
3.	Cantabria	Asturias				1
4.	Pias Vasco					
5.	Navarra					
6.	La Rioja					
7.	Aragon					
8.	Madrid					
9.	Castilla Leon	Galicia	Asturias	Extremadura		3
10.	Castilla La Mancha	Andalucia	Murcia	Extremadura		3
11.	Extremadura	Castilla Leon	Castilla La Mancha			2
12.	Cataluna					
13.	Communidad Valencia	Murcia				1
14.	Andalucia	C.L. Mancha				1
15.	Murcia	C.L. Mancha	Communidad Valencia			2
					$I_k =$	16

TABLE 6C.2

REGIONAL DATA SPAIN:BORDER REGIONS PORTUGAL AND FRANCE 1990 1998

				Per Capita Income (Y/P)			Population (x 1,000) P			Number of Firms n			Number of Employees L			Man. Empl. / Population L/P			Wages & Salaries w		
		SPAIN,PORTUGAL		1990	1997	Diff.	1990	1997	Diff.	1990	1997	Diff.	1990	1997	Diff.	1990	1997	Diff.	1990	1997	Diff.
		CORE																			
es21	76	4 Pias Vasco	C4:1	90	94.0	4.0	2160	2061	-99	8514	8430	-84	220250	197118	-23132	10.2	9.6	-0.6	3439.1	3886.5	447.4
es3	80	8 MADRID	C	96	101.2	5.2	5028	5023	-6	11652	17784	6132	242553	266324	23771	4.8	5.3	0.5	3779.9	4795.5	1015.6
es51	84	12 Cataluna	C4:1	92	100.0	8.0	6166	6064	-103	32335	40381	8046	551323	614109	62786	8.9	10.1	1.2	7457.1	10770.5	3313.4
pt11	167	16 Norte	C3:1	49	64.3	15.3	3453	3525	72	2404	41500	39096	272209	536516	264307.2	7.9	15.2	7.3	1446.1	3413.6	1967.5
		Open Economy (OE)		81.8	89.9	8.1	16807	16672	-135	54905	108095	53190	1286335	1614067	327732.2	8.0	8.3	0.3	16122.2	22866.1	6743.9
		Closed Economy (CE)		92.7	98.4	5.7	13354	13148	-206	52501	66595	14094	1014126	1077551	63425.0	8.0	8.4	0.4	14676.1	19452.5	4776.4
		OE - CE		-11.0	-8.5	2.4	3453	3524	71	2404	41500	39096	272209	536516	264307.2	0.0	-0.1	-0.1	1446.1	3413.6	1967.5
		SPAIN,PORTUGAL																			
		ADJACENT																			
es13	75	3 Cantabria	A1:1	74	77.4	3.4	535	527	-8	2357	1181	-1176	36005	29154	-6851	6.7	5.5	-1.2	458.8	565.3	106.5
es22	77	5 Navarra	A2:1	98	97.3	-0.7	527	528	1	3636	2041	-1595	62134	56801	-5333	11.8	10.8	-1.0	804.1	1247.2	443.1
es23	78	6 Rioja	A2:1	83	89.9	6.9	266	260	-6	2285	1716	-569	29633	28481	-1152	11.1	11.0	-0.2	279.7	438.3	158.6
es24	79	7 Aragon	A3:3	83	90.2	7.2	1201	1177	-24	7253	5121	-2132	95777	92736	-3041	8.0	7.9	-0.1	1199.6	1522.2	322.6
es41	81	9 Castillia-Leon	A2:1	67	76.6	9.6	2610	2506	-105	15031	7168	-7863	157364	132989	-24375	6.0	5.3	-0.7	1848.9	2269.9	421.0
es42	82	10 Castillia-La Mancha	A3:5	63	66.7	3.7	1695	1703	8	11866	7423	-4443	87403	89759	2356	5.2	5.3	0.1	713.8	1110.7	396.9
es52	85	13 Comuniaded Valencia	A1:2	74	75.8	1.8	3902	3922	20	24252	27266	3014	295767	324632	28865	7.6	8.3	0.7	2886.0	4237.2	1351.3
pt12	168	17 Centro (P)	A1:3	41	63.0	22.0	1723	1713	-10	1145	14762	13617	110537	171652	61115	6.4	10.0	3.6	668.3	1202.9	534.6
pt14	170	19 Alentejo	A3:4	35	64.2	29.2	543	524	-19	112	4465	4353	12918	22621	9703	2.4	4.3	1.9	83.1	170.0	86.9
		Open Economy (OE)		68.7	77.9	9.2	13002	12860	-142	67937	71143	3206	887537.8	948825	61287	7.2	7.6	0.3	8942.3	12763.7	3821.4
		Closed Economy (CE)		77.4	82.0	4.6	10736	10623	-113	66680	51916	-14764	764083	754552	-9531	8.1	7.8	-0.2	8190.9	11390.8	3199.9
		OE - CE		-8.7	-4.1	4.6	2266	2237	-29	1257	19227	17970	123455	194273	70818	-0.9	-0.2	0.5	751.4	1372.9	621.5
		SPAIN,PORTUGAL,FRANCE																			
		PERIPHERY																			
es11	73	1 Galicia	P1:2	58	63.6	5.6	2915	2720	-195	15168	9503	-5665	140997	143783	2787	4.8	5.3	0.4	1450.1	2098.9	648.7
es12	74	2 Asturias	P1:1	70	75.7	5.7	1124	1066	-58	4339	2757	-1582	83264	61108	-22156	7.4	5.7	-1.7	1254.9	1172.1	-82.8
es43	83	11 Extremadura	P3:2	49	54.5	5.5	1102	1078	-25	4841	2444	-2397	23843	23616	-227	2.2	2.2	0.0	175.6	245.1	69.5
es61	87	14 Andalucia	P1:3	57	58.1	1.1	7100	7156	56	20082	17713	-2369	209029	207404	-1625	2.9	2.9	0.0	2306.0	2988.7	682.7
es62	88	15 Murcia	P2:1	74	67.8	-6.2	1062	1091	29	4884	5019	135	64678	63912	-766	6.1	5.9	-0.2	519.0	735.2	216.2
pt15	171	20 Algarve	P2:1	49	74.1	25.1	340	345	5	59	2133	2074	6871	9935	3064	2.0	2.9	0.9	36.3	47.6	11.3
fr61	109	21 Aquitaine	P1:1	101	88	-13.0	2794	2900	106	2089	15527	13438	138644	150280	11636	5.0	5.2	0.2	2424.0	3324.9	900.9
fr62	110	22 Midi-Pyrenees	P1:1	91	83	-8.0	2431	2526	95	1934	14594	12660	116370	134414	18044	4.8	5.3	0.5	1998.7	3053.3	1054.6
fr81	114	23 Languedoc-Roussillon	P1:2	87	74.2	-12.8	2112	2278	166	1035	11611	10576	59978	72710	12732	2.8	3.2	0.4	1010.7	1577.4	566.7
		Open Economy (OE)		70.7	71.0	0.3	20980	21159	179	54431	81301	26870	843673	867162	23489	4.2	4.3	0.1	11175.3	15243.2	4067.9
		Closed Economy (CE)		61.6	63.9	1.5	13303	13111	-192	49314	37436	-11878	521810	499823	-21987	4.7	4.4	-0.3	5705.6	7240.0	1534.4
		OE - CE		9.1	7.1	-1.2	7677	8048	371	5117	43865	38748	321863	367339	45476	-0.5	-0.1	0.4	5469.7	8003.2	2533.5

Source: Eurostat 1993, 1999, 2000

TABLE 6C.2

REGIONAL DATA SPAIN:BORDER REGIONS PORTUGAL AND FRANCE 1990 1998

		Gross Investment K			Number of Employees / Firm L/n			Avg Wages & Salaries per Employee w/L			Gross Investm. per Firm K/n			Nominal Wages per Firm w/n			Gross Investm. per Labourer K/L		
SPAIN,PORTUGAL		1990	1997	Diff.	1990	1997	Diff.	1990	1997	Diff.	1990	1997	Diff.	1990	1997	Diff.	1990	1997	Diff.
4 Pias Vasco	C4:1	798.7	1328.0	529.3	25.9	23.4	-2.5	15.615	19.717	4.102	93.8	157.5	63.7	0.404	0.461	0.0571	3.6	6.7	3.1
8 Madrid	C	1046.4	1548.5	502.1	20.8	15.0	-5.8	15.584	18.006	2.422	89.8	87.1	-2.7	0.324	0.270	-0.0547	4.3	5.8	1.5
12 Cataluna	C4:1	2065.9	3567.0	1501.1	17.1	15.2	-1.8	13.526	17.538	4.013	63.9	88.3	24.4	0.231	0.267	0.0361	3.7	5.8	2.1
16 Norte	C3:1	501.5	1876.0	1374.5	113.2	12.9	-100.3	5.312	6.363	1.050	208.6	45.2	-163.4	0.602	0.082	-0.5193	1.8	3.5	1.7
Open Economy (OE)		4412.5	8319.5	3907.0	44.2	16.6	-27.6	12.509	15.406	2.897	114.0	94.5	-19.5	0.390	0.270	-0.1202	3.4	5.5	2.1
Closed Economy (CE)		3911.0	6443.5	2532.5	21.2	17.9	-3.4	14.908	18.420	3.500	82.5	111.0	28.5	0.320	0.332	0.1282	3.9	6.1	2.2
OE - CE		501.5	1876.0	1374.5	23.0	-1.3	-24.2	-2.399	-3.014	-0.603	31.5	-16.5	-48.0	0.070	-0.063	-0.2484	-0.5	-0.6	-0.1
SPAIN,PORTUGAL ADJACENT																			
3 Cantabria	A1:1	144.5	200.8	56.3	15.3	24.7	9.4	12.744	19.390	6.647	61.3	170.0	108.7	0.1947	0.4787	0.2840	4.0	6.9	2.9
5 Navarra	A2:1	243.6	388.2	144.6	17.1	27.8	10.7	12.941	21.957	9.016	67.0	190.2	123.2	0.2211	0.6111	0.3899	3.9	6.8	2.9
6 Rioja	A2:1	94.5	168.5	74.0	13.0	16.6	3.6	9.438	15.389	5.951	41.4	98.2	56.8	0.1224	0.2554	0.1330	3.2	5.9	2.7
7 Aragon	A3:3	347.3	566.0	218.7	13.2	18.1	4.9	12.525	16.414	3.889	47.9	110.5	62.6	0.1654	0.2972	0.1319	3.6	6.1	2.5
9 Castilla-Leon	A2:1	484.6	1168.8	684.2	10.5	18.6	8.1	11.749	17.068	5.319	32.2	163.1	130.8	0.1230	0.3167	0.1937	3.1	8.8	5.7
10 Castilla La-Mancha	A3:5	292.8	498.1	205.3	7.4	12.1	4.7	8.167	12.374	4.207	24.7	67.1	42.4	0.0602	0.1496	0.0895	3.4	5.5	2.2
13 Communidad Valencia	A1:2	1056.5	1369.4	312.9	12.2	11.9	-0.3	9.758	13.052	3.295	43.6	50.2	6.7	0.1190	0.1554	0.0364	3.6	4.2	0.6
17 Centro (P)	A1:3	255.1	834.2	579.1	96.5	11.6	-84.9	6.046	7.008	0.962	222.8	56.5	-166.2	0.5837	0.0815	-0.5022	2.3	4.9	2.6
19 Alentejo	A3:4	46.1	316.5	270.4	115.3	5.1	-110.3	6.432	7.515	1.083	412.0	70.9	-341.1	0.7418	0.0381	-0.7037	3.6	14.0	10.4
Open Economy (OE)		2965.0	5510.5	2545.5	33.4	16.3	-17.1	9.978	14.463	4.485	105.9	108.5	2.7	0.2590	0.2649	0.0058	3.4	7.0	3.6
Closed Economy (CE)		2663.8	4359.8	1696.0	12.7	18.5	5.9	11.046	16.521	5.500	45.4	121.3	75.9	0.1437	0.3234	0.1798	3.5	6.3	2.8
OE - CE		301.2	1150.7	849.5	20.7	-2.2	-23.0	-1.068	-2.058	-1.015	60.5	-12.8	-73.2	0.1154	-0.0586	-0.1739	-0.1	0.7	0.8
SPAIN,PORTUGAL,FRANCE PERIPHERY																			
1 Galicia	P1:2	361.6	935.2	573.6	9.3	15.1	5.8	10.285	14.597	4.313	23.8	98.4	74.6	0.0956	0.2209	0.1253	2.6	6.5	3.9
2 Asturias	P1:1	152.6	517.1	364.5	19.2	22.2	3.0	15.071	19.181	4.110	35.2	187.6	152.4	0.2892	0.4251	0.1359	1.8	8.5	6.6
11 Extremadura	P3:2	307.0	114.1	-192.9	4.9	9.7	4.7	7.365	10.377	3.012	63.4	46.7	-16.7	0.0363	0.1003	0.0640	12.9	4.8	-8.0
14 Andalucia	P1:3	771.8	1548.6	776.8	10.4	11.7	1.3	11.032	14.410	3.378	38.4	87.4	49.0	0.1148	0.1687	0.0539	3.7	7.5	3.8
15 Murcia	P2:1	138.0	785.6	647.6	13.2	12.7	-0.5	8.024	11.503	3.479	28.3	156.5	128.3	0.1063	0.1465	0.0402	2.1	12.3	10.2
20 Algarve	P2:1	7.9	20.0	12.1	116.5	4.7	-111.8	5.287	4.791	-0.495	133.7	9.4	-124.3	0.6157	0.0223	-0.5933	1.1	2.0	0.9
21 Aquitaine	P1:1	890.2	1202.1	311.9	66.4	9.7	-56.7	17.484	22.125	4.641	426.1	77.4	-348.7	1.1604	0.2141	-0.9462	6.4	8.0	1.6
22 Midi-Pyrenees	P1:1	872.0	1647.6	775.6	60.2	9.2	-51.0	17.175	22.716	5.540	450.9	112.9	-338.0	1.0335	0.2092	-0.8242	7.5	12.3	4.8
23 Languedoc-Rousillon	P1:2	572.9	977.5	404.6	57.9	6.3	-51.7	16.851	21.694	4.844	553.5	84.2	-469.3	0.9765	0.1359	-0.8406	9.6	13.4	3.9
Open Economy (OE)		4074.0	7747.8	3673.8	39.8	11.2	-28.5	12.064	15.711	3.647	194.8	95.6	-99.2	0.4920	0.1826	-0.3095	5.3	8.4	3.1
Closed Economy (CE)		1731.1	3900.6	2169.6	11.4	14.3	2.9	10.355	14.014	3.700	37.8	115.3	77.5	0.1284	0.2123	0.8386	4.6	7.9	3.3
OE - CE		2342.9	3847.2	1504.2	28.4	-3.1	-31.4	1.709	1.697	-0.053	157.0	-19.7	-176.7	0.3636	-0.0297	-1.1481	0.7	0.5	-0.2

CHAPTER 7

CONCLUSIONS OF THE DISSERTATION

1.1 Final Observations

The objective of this dissertation was to empirically examine the forces of agglomeration and dispersion as they are theoretically described in the core periphery model of the new international trade literature (Krugman, 1991b). In light of the increased trade liberalisation between countries forming regional economic associations in the past two decades, enlarged market size and increased competition challenge the strategic behaviour of corporations and medium size businesses. Their desire and innate behaviour for a profitable organisation sets in motion the dynamic forces of agglomeration and dispersion of industry –a force, which has the power to alter economic structures, incomes, and levels of welfare.

The 1992 Treaty of Maastricht formally created a common market between the fifteen member countries of the European Union. The removal of quantitative and qualitative trade barriers in the EU set in motion agglomeration and dispersion forces restructuring industry composition and concentration in the member countries. Shortly after the inception of EU 1992, economists began to empirically examine the effects of trade liberalisation on not only industry concentration (Brülhart and Torstensson, 1996), but also the characteristics of relocating industries (Haaland *et.al.*,1999; Forslid *et.al.*,1999; Davis and Weinstein, 1998; 1999). In a definitive article Midelfart *et.al.*, (2000) find a strong interaction between industry characteristics and the country characteristics that influence the location choice of industries. They find that industry in the EU has become more dispersed due to manufacturing growth in the southern EU countries.

The common thread running through the empirical research is that the EU is divided into central and periphery countries in accordance with the core periphery theory of the new economic geography (Krugman and Venables, 1990; Krugman, 1991b). Industry location and concentration is examined at the national country levels with imperfect international labour mobility. Davis and Weinstein (1999) are the first to deviate from the national country path by examining industry relocation and concentration at the Japanese prefecture level. Based on their analysis, they find strong home market economic geography effects under conditions of perfect domestic labour mobility. However, in the EU no attempt has been made to empirically examine the effects of EU trade liberalisation on industry location and concentration at the national regional geographic level with perfect domestic labour mobility to reinforce agglomeration and dispersion effects.

This dissertation has filled that gap in the empirical literature. In order to examine agglomeration and dispersion forces at the national regional level, the core periphery model was modified with a third region, an adjacent region, lying geographically between a core and periphery region. This third region is significant for the analysis from the very practical point of view that national regions have more region types than simply the characteristics of a core and periphery region. By examining the work of regional economists (Paelinck and Nijkamp, 1975), we found not only a nomenclature for national regions, but also a description of their characteristics. Introducing the adjacent region into the analysis was important because it provided a seamless continuum of production locations between the regions *within* a country. In terms of concentric circle theory, the adjacent region allows for the diffusion of production activities radiating outwards in all directions from the core. This three region regional model permitted us to examine the economic interaction between national regions where the effects of trade liberalisation are first encountered.

The CAP model is significant as an analytical tool for empirical research at the regional level for a number of reasons. First, it demanded a definition of the home market, a term in the theoretical literature that has never really been clearly defined, but is essential for conceptual and empirical clarity. Second, the model has allowed us to clearly categorise regions types and identify their geographic locations throughout the European Union. Third, once regions were identified in their CAP clusters the seamless diffusion path from core to periphery was also identified. This facilitated the application and measurement of Krugman's (1991a) industry index to examine the degree of convergence or divergence between regional industry structures. Fourth, the model required the development of *one* regional industry concentration ratio to measure both relative and absolute concentration. This regional industry concentration measure provided outcomes that allowed us to determine relative and absolute concentration and the extent to which these concentrations changed because of trade liberalisation. Fifth, the model allowed for the application of spatial correlation analysis to measure, at the regional levels, the effects of agglomeration and dispersion forces the convergence or divergence of regional demographic and micro-economic industry financial variables. Sixth, the model permitted a measurement of converging or diverging industrial structures and average wage levels between foreign border regions.

Specifically, when applied to the EU the CAP model has allowed us to identify the EU geographic core and the EU geographic periphery along with their independent agglomerates. The stylised EU facts support the format of the CAP model and shows that the regional data behaves in accordance with the theory of the new economic geography. The regression equations support the existence of a CAP framework, but needs to be re-estimated with interaction variables.

The CAP model reveals its most interesting results at the country level when applied to Spain. Here also the data behaves as would be expected from economic geography theory. Spain has three core agglomerates of unequal size, geographically located in the east, the centre, and the west. Industries with strong home market economic geography effects are all located in the core agglomerates. These industries are characterised by an absolute concentration level. Industries that are relatively concentrated in one core region are in most cases also relatively concentrated in the other two core regions, indicating a clear multi-agglomerate production structure in Spain. The data reveals a strong tendency for upstream and downstream industries to locate in a common core region or in a combination of core and adjacent regions. There is strong evidence suggesting the creation of economic districts between core and adjacent regions through intersectoral and interindustry linkages.

The spatial correlation analysis reinforces the industry index analysis and reveals a strong convergence between core and adjacent regions in the first concentric circle. The competition effect in the adjacent regions resulted in a 'catching-up' effect with the core regions. This effect was evident in average wage per employee, average number of employees per firm, and average gross investment per firm. Similar convergence effects occurred between the adjacent and the periphery regions. In the periphery regions this resulted in significant levels of gross investment to create economies of scale in production. The effects of trade liberalisation were distinctly felt in foreign border regions. In Spain, its southern periphery regions showed a divergence of industry structures with the domestic core region, and a greater convergence with industry structures in Portugal. In the northern regions of Spain, there is a convergence of wages with the French border regions, suggesting the Stolper-Samuelson factor-price equalisation effect.

Finally, trade liberalisation has increased industry concentration predominantly in the core and adjacent regions. It would appear that the country characteristics of Spain – a skilled labour force, technological knowledge, geographic location, and a favourable wage differential – make it attractive for industry location. It is entirely possible that the growth of manufacturing industry in Spain has exceeded that in the EU geographic core.

1.2 Further Research

In the first instance, the regression equations for the EU regions need to be re-estimated using interaction variables. In the second instance, the outcomes in this dissertation need to be followed up with empirical research to examine regional economic policy measures that stimulate the development of regions. In particular, research should examine the type of economic policies that stimulate the development of economic districts, i.e. core and adjacent regions. The economic development of the Spanish border regions, with their French and Portuguese counterparts, should be further examined for the policy implications for regions of the eastern European countries about to join the EU.

Since the model focuses on regional economic geography and industry location, further research should examine homogenous industrial districts and their industrial composition. This could be accomplished through cluster analysis, and/or principle component analysis and would reveal the inter-industry relationships.

The CAP framework for regional economic geography analysis has proven to be fruitful. For any meaningful international comparisons the model should be applied other European periphery countries, or for that matter, EU core countries. Identifying the regional concentration of production activities in central EU countries would complement the current empirical research conducted on the EU. Of greater interest perhaps is the fact that the model can be applied to the regions of countries in relatively new regional economic associations at the customs union stage. Given that we now have witnessed how industry has responded to trade liberalisation, the model could provide relevant information for guiding regional economic development.

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