Advances in Spatial Economic Theory:

New Techniques for the Analysis of Agglomeration

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Declaration

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidacy for any degree.

The thesis is the result of my own investigation except where otherwise attributed. Other sources are acknowledged by explicit references. The bibliography is appended.

I hereby give consent for my thesis, if accepted, to be available for photocopying and for interlibrary loan, and for the title and summary to be made available for outside organisations.

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Go Raibh Mile Maith Agat

Abstract

Economic clusters have been one of the key research areas of the new economic geographers over the last 25 years. The topic has received much attention from policy makers and academics alike, however, there has been a great deal of confusion both in terms of defining and identifying a cluster. This work seeks to reincorporate traditional economic thinking into the study of clusters by bringing back the focus of this phenomenon through a spatial diagnostic framework, allowing the construction of a new theoretical model. After reviewing a large number of studies, it has become clear that methodological approaches need to incorporate more of an intuitive element, thereby reflecting the fluidic nature of a cluster. The research draws on the method constructed by De Propris (2005) and applies it to manufacturing data from South Wales. The results give a contemporary description of the distribution of industry in the region, but fail to show the existence of clusters. The method was found to be inconsistent when applied to disaggregated data, which prompted an investigation into what a cluster is thought to be and how they link into the traditional agglomeratory notions of Marshall (1890).

Firstly, the traditional tool of cluster investigation, (i.e. the location quotient) was amended to allow for variance. This was then complimented with the construction of a new decomposition model that enables a more detailed position of analysis to be achieved rather than making gross generalisations about individual sectors. The results for both methods when applied in South Wales have been positive, permitting more detailed information about sectoral specialisations to be uncovered. Finally, a new measure of agglomeration was introduced that is able to capture the main attributes of the force. This work has devised new methods of analysis and prompted a rethink regarding economic clusters as well as advocating the continued development of more detailed spatial frameworks in the future.

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Chapter 1 Introduction

"Everything is related to everything else, but near things are more related than distant things." First Law of Geography [Tobler, 1970, p.236]

1.1. Introduction to the Research Issue: A Methodology Based Thesis

In the twenty-first century, in an age of computers and complex communication networks, economic geography could be thought of as taking a back seat to the virtual economy growing around us. However, this is not the case and in particular, one area of research has grown more than any other. The term economic cluster has become a popular word in government policy and in the field of regional development. This concept or phenomenon continues to flourish both in the world of academia and in the applied business environment. What is more interesting to note is the background to this concept. One of the persistent flaws among most policy makers is the belief that an "economic cluster" is a new idea, a new way of conducting economics. Even more disturbing is the notion of the ease in creating economic clusters for the purposes of economic development.

This work wishes to re-examine current thinking on economic clustering by tracing its roots from the early spatial economic theories of the 1800's through to the New Economic Geography theory being developed today. Sir Isaac Newton once wrote "If I have seen a little further it is by standing on the shoulders of Giants".

These words should be the corner stone of any research field especially one which has such a long and well established past as spatial economics. Although new phrases and commercial spin may be employed, the academic rigour and long thought out theory should not be easily cast aside to make room for more digestible notions of economics.

The term economic cluster may have been coined by Michael Porter of Harvard University but its deeper meaning has its roots in the work of one of the fathers of modern economic thinking. In 1890 Alfred Marshall published one of the defining literary economic works seen since Adam Smith's "Wealth of Nations". "Principles of Economics" transformed individual theories of supply, demand and production into a coherent description of the world. What Marshall also considered in his work were the implications of the geographical proximity of firms. He talked of agglomeration, as firms in close proximity to one another so as to obtain advantages symbiotically not possible if they were alone. His work, almost one hundred years before Porter, introduced this concept which was almost over- looked by the emerging field of economics during the early twentieth century.

Porter's (1998) rebranding and introduction of the cluster back into economic consciousness has been both a saviour and a sin. In the rush to disseminate academic thought the concept of economic cluster has become disjointed and confused. What was originally a phenomenon has been seen as an economic tool, through which governments can create new channels of economic growth. In fact, reports such as DTI (2000) and McCormick (1999) talk of building clusters for regions, in order to re-establish mechanisms of industrial growth.

1.2. The Non Existence of a Unified Cluster Theory

This new-found interest in the concept of a cluster has left the academic world with a problem. Practitioners are keen to know how to use a "cluster" as an economic development instrument, possibly at the expense of the academics who wish to develop a greater theoretical appreciation for the concept. This divide could very well engulf the whole notion of a cluster thus reducing a powerful economic phenomenon to nothing more than a regional economic branding tag used by governments. Reich (1990) shares this concern and notes how public discourse can take something from obscurity to meaninglessness, completely passing by a period of understanding. A report by the Danish Research Unit for Industrial Dynamics (DRUID) published in 2005 entitled "What Qualifies as a Cluster Theory" investigates the frequency of academic writings on the different strands of cluster theory. Between 1950 and 1980 not one paper used the term economic clusters with less than 120 academic articles being published on the field in general. During the 1990's this all changed, around 600 journal articles in 10 years were published. As noted in the report, large numbers of economists and regional scientists began to redevelop an interest into economic geography. What makes even more astounding reading is that from 2000 until September of 2004 almost 700 articles were published. In less than two decades a field ignored for close to a century has been radically and brutally exhausted from every imaginable angle. The problem that this has created is two-fold, the first being the ignorance of some to the pre-Porterian understanding of a cluster, secondly the confusion over the concept of a cluster.

Post- Porterian ideals of clusters are based upon the notion of clusters being at the heart of creating competitive advantage for countries as well as regions. Clusters are seen as almost a strategic move for firms, a tool by which one company can choose to compete with another. Porterian clusters derive the mechanisms of operation from the value chain concept Porter (1998). This is firms up and down the supply stream existing in close proximity thus enabling the transference of information and resources at a reduced cost and more efficiently thus increasing the marginal product of output for all members of the cluster.

This very static and quite restrictive idea of a cluster has been used by many government agencies as a template for how clusters work, for example in the UK the DTI. The problem with this notion is that it ignores the idea of clustering as a phenomenon possibly naturally occurring across economic space, caused by unknown interactions but creating extraordinary outcomes. The idea of clusters being a natural part of the economic environment is not such an alien notion if one simply considers the initial spatial economic work of Von Thünen (1826). The concepts of economic space were very different than what they are today, being more concerned with individual product construction achieved from the basic sectors. However, what it did do was give the choice to a firm of how to produce the goods with relation to the market. It may seem a simple notion, but by this occurring for thousands of different firms, generation after generation would build up some interesting macroeconomic patterns. It may also be questioned if the very nature of social structures leads to the clustering of firms, or whether it is just the transactional relationship that leads firms to establish the spatial patterns they do?

The second major problem, as noted by the work of Martin and Sunley (2003), is the confusion over exactly what a cluster is. Numerous definitions have been introduced, as well as many different economic frameworks designed to capture the effects of the cluster. The problem, as noted by many, is the lack of consistency in analysis, across both different fields as well as from different academics in the same fields. Some underlying benefits appear over and over again, such as the presence of knowledge spillovers and productivity increases, but rarely are the dynamics explained. One of the key reasons why this confusion has arisen is the Porterian understanding of a cluster. Porter has never attempted to construct a theory about the existence of a cluster (Maskell et al,2005). This has created a circular problem, authors inspired by Porter take a similar approach, and they predominantly explain what a cluster is rather than theorising over its formation.

1.3. Research Objectives

What some of the aforementioned research work has tended to overlook are the original writings of Marshall. This work seeks to reincorporate this traditional thinking into the study of clusters. More importantly, this work seeks to bring back the focus of this phenomenon through a spatial economic framework, creating new techniques that allow the construction of a new theoretical model. The region of South Wales has been chosen as the base of study for this research. South Wales has the highest concentration of manufacturing in the UK and has been seen, in the past, as the power house of industrial Britain. The region has however undergone massive economic change with the decline in heavy industry. Thus it also provides an opportunity to investigate the agglomeration or clustering of industrial sectors in a manufacturing dominated area. This is demonstrated by previous studies, e.g. De Propis (2005), which also allows comparisons of the analytical tools developed.

More specifically this thesis will survey the existing available methods within spatial economic analysis focusing on the spatial distribution of economic activity. It intends to utilise existing methodological approaches used to identify "clusters" and refine them in order to improve their use. Three important contributions will be made by this work. The first is to improve the existing (Location Quotient, or LQ) techniques used in "cluster" analysis. The second is to develop new methods for identifying agglomerations of industry in particular. The final contribution is to apply these improved and new techniques to the case study region of South Wales, and so evaluate the value of these techniques in policy making.

In trying to improve existing techniques the research will seek to develop a method capable of showing the significance of traditional Location Quotient values for industries. It will do this by augmenting traditional "point estimates" to include a variance found by identifying the quotient's constituent parts.

The construction of a new method agglomeration analysis will focus on the characteristics, most often noted in the literature, as being associated with agglomeration. While doing this the research questions the definition of an economic "cluster" and brings about a shift in thinking regarding agglomeration. Defining a cluster is the key aspect to this work. Agglomeration and clustering must not be considered interchangeable when used in the context of a quantitative method. Table 1 therefore details the definitions to be used in this work.

Table 1. Clustering and Agglomeration Definitions

Phase	Characteristic (Structure & Space)	Classification	Level of Aggregation for Identification*
1	Industries in the same location	Concentration	2 Digit
2	Specialised Sectors	Specialisation	4 Digit
3	Concentrations of specialised sectors of an industry	Specialised Concentration	2&4 Digit
4	Attributes of both the other phases, but also transactional interaction between these sectors	Agglomeration	2&4 Digit

For the purposes of this research it must be outlined from the start what is defined as a sector and what is defined as an industry. To alleviate the problem of semantics created by the Standard Industrial Classification (SIC) used in the UK, it has been decided that 2 digit SIC data, that is low level disaggregation, represents a whole industry. 4 digit, highly disaggregated data is able to identify individual sectors. It is implied from this that industries E.g. SIC 15 is made up of the sectors 1534, 1536, etc.

These definitions, whilst restrictive, allow a detailed analysis of agglomeration without suffering from the semantic as well as general confusion problems suffered in other research. The new method, in this work called the C statistic (Crawley statistic) is designed to better identify a very specific notion of agglomeration that is traded highly intensive manufacturing concentrations.

The final part of the work will apply these existing techniques to the test region of South Wales to evaluate the improvements the new statistics make in identifying attributes of industrial structure and thus assist in policy.

The region this work will focus on is South Wales. In applying the new methods (improved LQ and the C statistic) the work tests the techniques themselves for reliability and secondly what they identify as being agglomerations of industry in South Wales. By looking at South Wales it is possible to compare the findings of the new methods with that of the official DTI cluster report published in 2000 for the region.

Where this research will also differ from previous work in South Wales is the level of disaggregation in the data used. Large scale studies such as De Propris (2005) used 2 digit SIC data to calculate concentrations of industry. This study will use 4 digit SIC data as well as the multi-procedural approach adopted by De Propris (2005). It is these two key factors which will provide a framework to begin an agglomeration analysis.

It must be emphasised at this point, however, that the term economic clusters is not applied to any of these findings. Agglomeration specifically is the focus of the investigation.

1.3.1. The Structure of this Thesis

The remained of the thesis is structured as follows:

Chapter 2 Theoretical Review of the Literature Related to Agglomeration

This chapter explores the historical background to spatial economic analysis. It draws together many schools of thought from the early 1800's through to the 21st century. The goal is to see the development from simple one input spatial models to the present and analytically superior New Economic Geography models. This in-depth historical approach to the literature review is essential in trying to redevelop a field of study which has become cluttered with unnecessarily theoretically barren work. The mathematical derivation of models is also included where necessary, to allow comparison between differing models.

Chapter 3 Economic Clusters

This chapter focuses on the emerging cluster literature across different fields including regional economics and geography. The work will first examine the popular theories and definitions of what a cluster is before moving on to their exploration through current literature. The benefits and disadvantages of clusters will also be appraised from both theoretical and policy orientated literature. A particular focus of the chapter will be to examine existing cluster analysis, namely the 2000 DTI report.

Chapter 4 Methodology Chapter: Identifying and Measuring Clusters

This chapter explores the issues from the literature examined in the previous chapters. In doing so it focuses on the quantitative techniques currently used in the study of economic "clusters" and outlines the contribution of new methodological approaches to the issue. The most common methods such as the LQ are considered in detail and appraised for their contribution to "cluster" analysis. The work moves on to look at other specialisation measures as well as concentration statistics. Lastly, the chapter examines the use of denominator values in traditional LQ calculations. A brief comparison of UK and Welsh level denominators is then used to illustrate difference in the results obtained.

Chapter 5: Spatial Concentrations of Manufacturing in South Wales

This chapter gives a brief background to the region under study (South Wales) before introducing and applying the methodological approach of De Propris (2005) then applying confidence intervals to 4 digit rather than 2 digit data for LQ' TTWA's. These results will allow the drawing of new industrial maps for the region. The research will also allow clusters of specific industries to be identified, (based upon the definition of the De Propris classification). This methodology is coupled with a temporal analysis of the region, thus allowing any underlying trends to be discovered. The findings are analysed and discussed in depth before also questioning the weaknesses of the existing data. The second half of the chapter will improve the existing LQ methodology through the calculation of the relative significance of a measure based upon a mathematical method known as the delta approximation. This is then used to calculate confidence intervals for the LQ's. Finally, the results are discussed with relation to sector specialisation in the South Wales region

Chapter 6: Measuring Agglomeration and Applications of the Statistics

This chapter explores a new way of thinking about "clusters" based upon the initial results from chapter 5 before exploring the notion of agglomeration further. The chapter moves on to utilise the C statistic developed in chapter 4. The chapter compares the C statistic to the existing Ellison and Gleaser (1997) G statistic. The results are examined along with associated statistics to determine how these levels compared to the findings from both chapters 4 and 5.

The chapter ends with a comparison of the concentration ratio and the new agglomeration statistic. The discussion looks at the advantages and disadvantage of both techniques and the implications of the results for South Wales, focusing on what has been learnt by using the new technique.

Chapter 7 Conclusions

This chapter draws together the major findings from this work and tries to evaluate its contribution to regional economics. Most importantly it highlights the new theoretical contribution of this work and urges the continued developed of this area. It also addresses the policy implications of the work with emphasis on regional development policy and cluster use both for Wales specifically, but also more widely. The final section of the chapter considers where the research agenda could focus its agenda next.

1.4. Type and Sources of Data

One of the main sources of data to be used will be confidential work place analysis compiled by the Office of National Statistics under the auspices of the Nomis, which produce labour market statistics for the UK. The data are estimated based upon multiple techniques including questionnaires, and interviews. The agency does warn of estimation errors but do not give precise figures for the variance. The data extracted is for a number of different years identified in the sections of the thesis where it is being used. The second source of data is the national input output tables for the UK for 2004. These tables are also compiled by the same agency but are free to view by all. For a full discussion on the data used in the thesis please refer to Chapter 4 methodology.

1.5. Relevance, Scope and Limitations of the Work

The continuing interest in economic clusters makes this work of critical importance to both policy makers and academics alike. The confusion and misunderstandings as to the nature of this phenomenon mean that further development is hindered greatly. By re-examining the concept from a traditional perspective and trying to theorise as to its occurrence, new light will be shed on an area cluttered with divergent thinking. By introducing new methods of analysis combined with traditional techniques it is envisaged that the regional analyst be that academic or policy maker will be better equipped as a result of this work.

Although South Wales is used to conduct this study, it is intended that the techniques developed in this work be generalisable and applicable to any developed and possibly developing region. South Wales has undergone major economic change over the last 40 years yet its industrial base continues to form a major component of the economy. The new cluster maps drawn up in this project should give new insights into the distribution of industry in the region as well as helping to classify the areas of economic strength. The research has limitations like all projects of this scale. The work has deliberately focused on manufacturing and avoided looking at the service sector. This is not dismissing this form of cluster but the complexity involved in looking at multiple sectors of the economy could create problems when it comes to developing a replicable theory.

Chapter 2: Industrial Location Theory and Agglomeration

2.1. Introduction

This chapter will explore the literature over the past three decades that has sought to explore location theory. It will draw upon both empirical as well as theoretical work in order to better understand how firm location has been dealt with, as well as chronologically detailing the notion of agglomeration. The chapter will conclude by tracing the New Economic Geography (NEG) literature to its historical routes.

2.2. Background to Location Theory

Location economics has undergone somewhat of a makeover in the last 20 years. The new economic geographers in the seminal work of Fujita, Krugman and Venables have reinvented the field with new models focusing on the micro foundations of regional dynamics. But why is it important to understand the notion of location? Is the choice not simply an arbitrary concern of a firm? Within an age of global mobility in the factors of production it can be questioned how important location is to business. However research, in particular from Porter (1998), emphasises how important location is in firm performance and proximity amongst industries and is seen by many authors as bringing competitive advantage. In order to understand the distribution of industry today, it is therefore essential to understand the traditional economic thinking associated with industrial location in the past. The birth of location economics was firmly a German affair, with a plethora of research conducted by mathematical engineers who were driven by the belief that real science involved numbers rather than mere observation.

The initial forays first saw the light of day with the work of Von Thünen (1826) whose now seminal model compares the relationships between production costs, the market price and the transport cost of an agricultural commodity. Transport is the key argument within this relationship, land has mono-functional uses and these are distributed in concentric rings around the primary market place with the most productive sectors closest to the centre. The core assumptions are a closed economic system, and the homogeneity of land.

This work is heavily influenced by the Ricardian view of land where profitability determines the location of certain production. Hofe and Chen (2006) note that the microeconomic implication of this model's formation implies that there is always an upwards-sloping supply curve, which coupled with no allowance for factor substitution means the extent to which the model can be applied accurately to multi industry based space is minimal.

The model can be summarised as:

$$R = Y(p-c) - Yfm \qquad (1)$$

That is the rent per unit of land (R), is equal to the yield per unit of land (Y). This is multiplied by the price per unit of yield minus the production costs. The other side of the model takes the costs (f) associated with the distance from the market (m). The working of the model means what maximizes the use of the land is simply the distance from the market place, the most productive firms or those with high transport costs occupy the land closest. What can be understood from this first work is that the distribution of economic activity is governed by economic rents (Dunne, 1954).

2.3. The Evolution of Location Theory

Location theory evolved further with the work of Launhardt (1885) and Weber (1909). Instead of focusing on land and possible economic rents, as in the early work, the focus is instead on the firm's production function. Relationships within the models are explicitly expressed between the quantity of outputs produced and the quantity of inputs required. Location dynamic enters as an optimization problem, whereby firms try to minimize transport costs which are incurred as a result of greater distance from the market. With Launhardt's model it is essential to formalise the factors from the outset. The location is referred to as the isolated state, this is a closed market. The spatial area in question is seen as a Euclidean plane with the market being the origin. All points from this market are measured by the Euclidean Distance. The model is set as a production function which can be formalised as in the work of Fujita et al (2002) as:

$$q_i(r) = \frac{1}{\alpha_i} \qquad (2)$$

The production of one unit i requires the use of land units α_i, this is a positive constant not dependent on location. It can be assumed that this measure implies that a unit of land is a combination of land and labour as is explained further by the work of Lucas (2001). The distance from the market is given as r.To explain the model further price p_i and transport cost t_i of goods must be included which are taken to be constants. Like other problems of this nature, Launhardt like Thünen before him believed that a bidding process takes place between the agents vying for the land.

Individuals bid based upon the surplus capital that can be generated from using the unit of land. This surplus can be summarised as:

$$(p_i - t_i r)/\alpha_i \tag{3}$$

This surplus therefore is influenced by the activity as well as the location. It is possible to then calculate the bid rent $\Psi_i(r)$ for an area as well as the profit $\pi_i(r)$ an agent makes for an activity per unit of land at a given location.

$$\Psi_i(r) \equiv (p_i - t_i r)/\alpha_i \tag{4}$$

$$\pi_i(r) = (p_i - t_i r)q_i(r) - R(r) = \Psi_i(r) - R(r) \tag{5}$$

The result for (5) is obtained simply by combining (2) and (4), this is where $R(r)$ is the rent per unit of land, therefore proportional to the distance r. A land rent function R^* can now be derived which in turn predicts a competitive equilibrium.

This equilibrium implies that no producer finds it profitable to change location based on the existing rent. When combined with the principle of constant returns to scale and the assumption that equilibrium land rent cannot be negative the following is implied:

$$R^*(r) \equiv \max\left\{\max_{i=1...n} \Psi_i(r), 0\right\} = \max\left\{\max_{i=1...n}(p_i - t_i r)/\alpha_i, 0\right\} \tag{6}$$

At the end of the bidding process the agent who offered the highest bid owns each location. All the bid rent functions as given by (4) are said to be decreasing and linear in distance.

Fujita and Thisse (2002) make the proposition:

> *"The equilibrium land rent function is the upper envelope of all bid rent functions, and each crop is raised where its bid rent equals the equilibrium land rent. If the transport cost function is linear in distance, then the equilibrium land rent is decreasing, piecewise linear, and convex".*

It is possible, as done by Fujita and Thisse, to incorporate these findings to graphically illustrate Launhardt's findings combined with Thünen's earlier conclusions. Figure 1 (see overleaf) shows how the production of goods fit into a pattern of concentric rings. Thünen knew that competition between agents would lead to a gradient of land rents, with the market or town having the highest and the furthest cultivation of crops having the lowest. This like in Weberian work leads to a trade off between land rents and transportation costs. Thuen knew that yields of crops and transport costs were heterogeneous to different goods, for example, there are three different commodities r1, r2, and r3. Each of these goods are organised into concentric circles' around the market, their location determined by the profitability of the good. R represents bid rent or the price of the land and r represents economic space. Therefore the further out on the r axis, the greater the distance from the market. Ψ is the location choice of industry 1-3 respectively. The model is simple but yields some interesting insights not least the specialised structure of good cultivation, resulting in the concentration of industry.

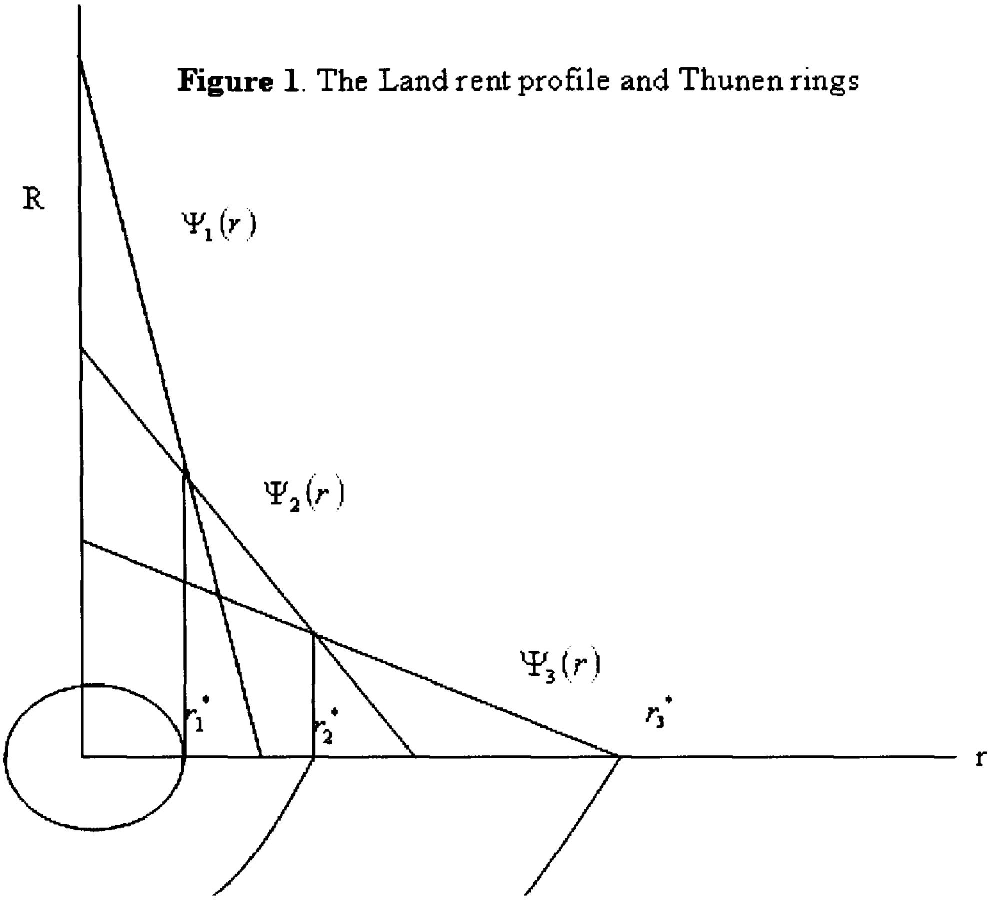
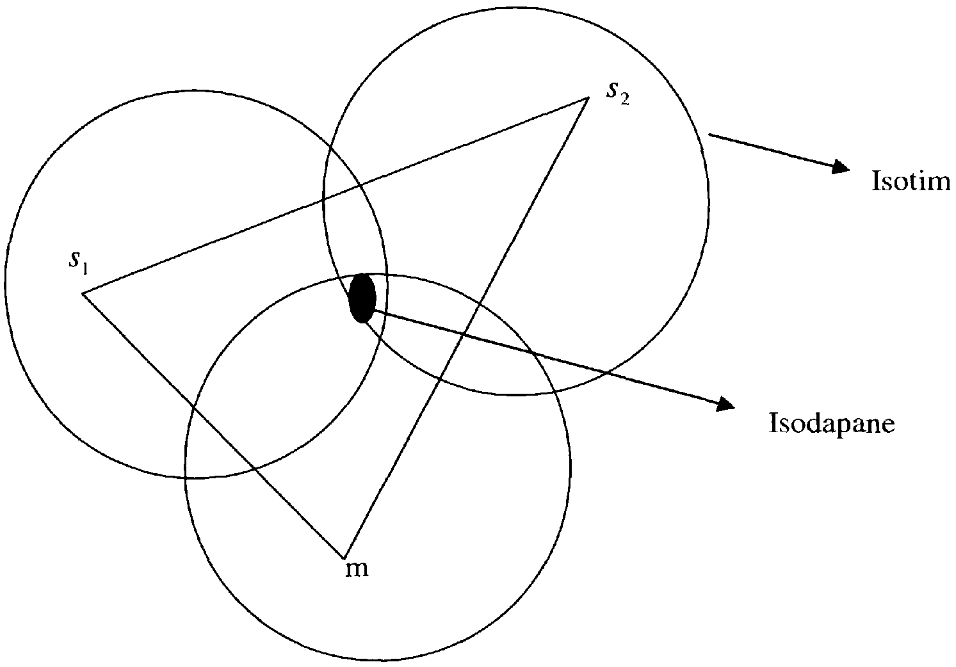


Figure 1. The Land rent profile and Thunen rings

Weber's 1909 work introduced a flurry of new terms into the literature along with a geometric model designed to show the force that transport costs exert on firm location. The Location triangle theory or Weberian triangle (see figure 2 overleaf) geometrically illustrates the relationship between two sources of inputs s_1 and s_2 and the market place m. The model considers the transport cost incurred by locating at s_1, s_2 and m. Firms will choose the area where the total transport costs are minimized. The input materials are classified under two headings, ubiquities and localised raw materials. Ubiquities are inputs, which are available at all locations and have no power in the influence of firm location. Localised raw materials are only available in certain locations and so govern the decision of firms to operate in one place or another.

Figure 2. Weber's Triangle



There are two primary iso- measures within the work, namely Isotim and Isodapane. Isotim are points which surround the localities of raw materials all having equal transport costs, which Isotim are only equal to the input s_1. Firms must also take into account the other two transport costs for s_2 and m.

What this results in is a lattice effect with firms choosing to operate between the overlapping isotim lines, a point which is referred to by Weber as the Isodapane. Essentially, this is the area around the minimum total cost point, which creates an incentive for firms to operate here. McCann and Sheppard (2003) talk of the significant shift in thinking between these early pieces of work.

Thünen's model revolves around a one-dimensional spatial framework, proliferated by the differentiation of land based upon location specific rental payments. This infers that the land rewards are the natural outcome of geographical space. The problem that this creates is that the outcome of this model is not one-dimensional but two and so the conclusions are immediately transposed into another meaning. The Launhardt-Weber work takes a different approach to the understanding of geographical space, immediately assuming a two dimensional form. Land does not appear to make any difference to the productive capability of firms, and the defining factor is the spatial transaction costs.

Both of these classical approaches to the study of location make the assumption of two forms of cost: location specific cost and distance related cost. By dividing the costs into these brackets and also defining the production function as done in the Launhardt-Weber models, it allows one to solve the location problem for a firm.

2.4. Marshall and Location Theory

The next major contribution to location theory added further important dynamics to the study and was the first to acknowledge what the work previously hypothesised about. Alfred Marshall whose seminal works the "Principles of Economics" 1890 began to construct a hypothesis for the spatial proximity of industry or the so-called agglomeration of economic activity. The writings concentrated on the development of industrial complexes, occurring from the existence of positive externalities, i.e. the beneficial effects of same space occupancy of interrelated firms and industries.

Principles of economics focused on these externalities occurring are due to three major forces: (a) knowledge spillovers between firms, (b) specialised inputs and services from supporting industries, and (c) a geographically pooled labour market for specialised skills. These three forces are thought to act as "magnetic pools" tying industries together.

Marshall himself states,

> *"When an industry has thus chosen a locality for itself, it is likely to stay there long: so great are the advantages which people following the same skilled trade get from near neighbourhood to one another. The mysteries of trade become no mysteries; but are as it were in the air, and children learn many of them unconsciously. Good work is rightly appreciated; inventions and improvements in machinery, in process and the general organization of the business have their merits promptly discussed: if one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of further ideas." (Marshall, 1890, IV, x, 3)*

What Marshall did, was explain why industries behaved the way they did and as a result, began to make economists and regional scientists think about external economies of scale.

The cumulative processes that were described in this work are essentially the interaction between pecuniary externalities and the laws of increasing returns and monopolistic competition (Matsuyama, 1995). This is discussed in more detail later when considering the work of Krugman (1991).

Marshall's work although paving the way in the field did have some weaknesses. Localization economies make the assumption that all firms and businesses belong to the same industry sector, as well as the fact that the proximity of such firms aids in the innovation process of the industry as a whole in that area. This principle means that within a given location, if one firm is performing well in terms of innovative performance then the other firms should also be experiencing the same thing. This idea served as the catalyst among geographers and economists over the following 20 years, to question what is the structure of Marshallian agglomerations?

This research agenda was again driven by German academics and the 1933 work of Walter Christaller. Christaller was concerned with town or market locations but his central contention was that industry appears to cluster together not just in geographical terms but also within structural terms. This is because clusters, or central places as he refers to them, are arranged in precise ways in terms of their comparative importance to one another Lloyd and Dicken (1977). The other assertion made in this work is that these central places primary function, is to provide the surrounding locality within which they operate with goods and services. The second important contribution that was introduced in the work was the concept of a hierarchy.

The hierarchy being referred to, is based upon the levels of order among its constituent parts. Goods and services are described as low and high order, determined by their so-called spatial range (the acceptable distance from the point of consumption allowing for transport costs). These different forms of hierarchy have certain distinct characteristics such as the fact that higher-level producing centres can have lower level activities around them but not vice versa.

In order to illustrate this point, let us consider services for a moment. Lower order services are seen as being simple activities, for example grocery stores, whereas higher-level services would include Universities, separated by the distance consumers are willing to travel in order to acquire particular goods. In essence, Christaller talks of ranking all goods and services based upon their demand by a dispersed population. The goods and services are given a threshold value: the higher the value, the more the population demands these goods or services. This means that, because these hierarchies exist within the central places for a given space, the number of centres producing certain goods will be proportional to the demand of the whole population.

A worked example of this model is presented by Lloyd and Dicken (1977), whereby an assumption is made that a specific space has ten goods and services, ranked 1-10 in descending threshold value; i.e. the lowest value goods have the highest demand. There are three centres A, B and C, A having the highest levels of hierarchy and C the lowest. Table 2 (overleaf) shows the patterns of spatial dispersion for the ten goods.

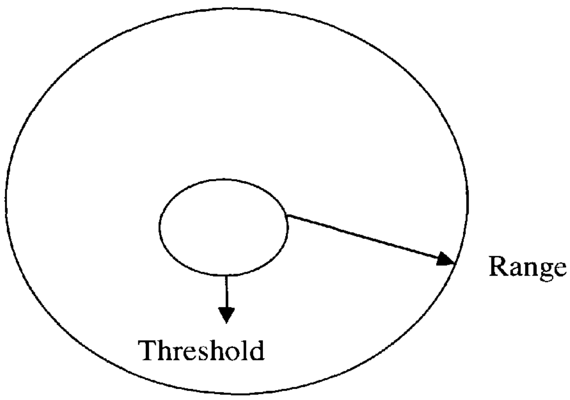
Table 2. Relationship between the order of goods and the central place hierarchy

Threshold Value		A Centres	B Centres	C Centres
High	1	*		
	2	*		
	3	*	*	
	4	*	*	
	5	*	*	
	6	*	*	
	7	*	*	*
	8	*	*	*
	9	*	*	*
Low	10	*	*	*

In this example, good 1 has the highest demand, therefore it needs to be produced in the highest order hierarchy centre A. The numbers of these three types of centres varies depending on the aggregate demand of a particular space. For example, if good 1 is demanded by 200, 000 people and there is a total population of 1 million people, then there can be no more than 5 A centres. Going back to the original 1933 Christaller work it is assumed that these 5 centres will be located equally distant from one another.

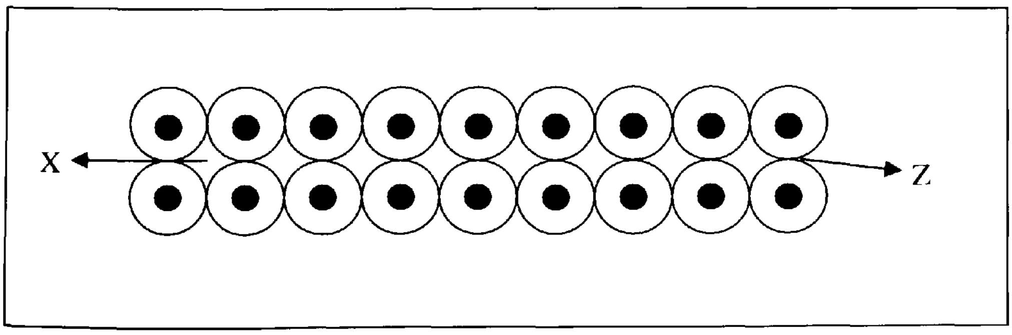
Distance is now included as Christaller attempts to link the threshold values and spatial units together in one form. Figure 3 shows how the two concepts work together.

Figure 3. Threshold, Range structure



The threshold value is obtained as previously explained. The range (distance) is the average maximum distance people will travel to procure the goods or service. In the above configuration, it is possible to piece together how the upper and lower order goods and services fit together in central places. Transport is assumed to be homogeneous and so does not vary in cost depending on direction from the centre. Each Centre has a circular market area and is configured as in Figure 4.

Figure 4. Configuration of Central Places



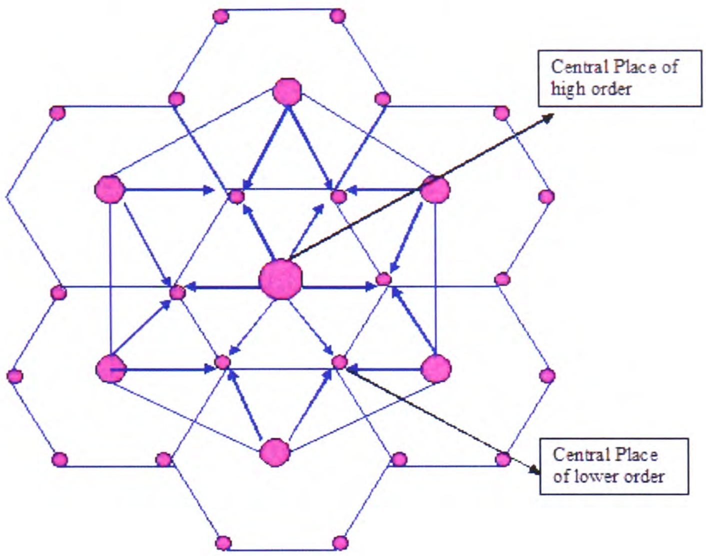
The primary problem with circular markets is that certain areas marked (x) are un-served and other areas such as z are over- served. This was remedied by Christaller by assuming that markets are hexagonal.

The spatial arrangements of the hierarchy result in the formation of three models, which arrange higher order places among lower order places, which is based upon the function of the central place. Christaller noted the centre could have three functions: marketing, transportation and administration, each of which divide the market area in different ways. The three models are identified by the size ratio K. The function or principles as they are also referred to are the fixed relationships between each level in the hierarchy. These three principles are described by the following size ratios:

- Market model K=3 (Figure 5)
- Transportation model K=4 (Figure 6)
- Administrative model K=7 (Figure 7)

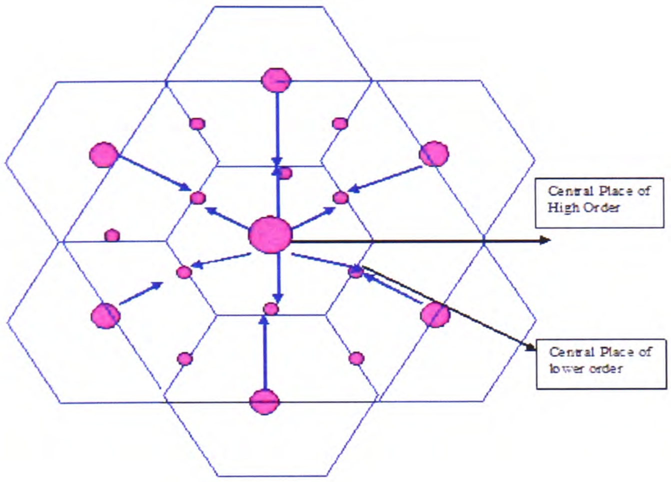
In the market model, (see figure 5 overleaf), when K=3 the market area of a higher-order centre will also include a third of the market area of each of the lower order centres around it. These are located on the corners of a hexagon around the high-order centre. Each high-order centre follows this pattern and so each gets 1/3 of lower order areas, thus K=1+6*1/3=3. Christaller noted that this is cumbersome and that transport is not considered in the most efficient way.

Figure 5. Marketing principle in Christaller model



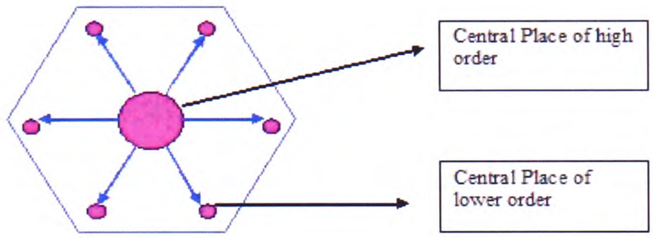
In the transportation model, where K=4 , even with the assumption of direction not being important from central places due to homogeneity within transport costs, some directions are more likely than others. When this is taken into account lower order centres are located at the midpoint of each side of the hexagon. The market area of a higher-order place includes a half of the market from each of the neighbouring lower-order centres around it. This results in the most efficient transport solution (see figure 6 overleaf).

Figure 6. Transport principle in Christaller model



Finally there is the administrative model, (see figure 7 overleaf), where K=7. In some later works such as Shonkwiler (1996) this became known as the political-social principle due to the relationship of the governmental centre serving the places adjoining it. This represents where all the lower order centres operate within the same market as the higher order. The principle says that markets cannot be split up administratively, i.e. lower order centres must be allocated to a locality within a higher order. This is due to the inefficiency in lower order centres administration compared with that of the higher.

Figure 7. The administrative principle in Christallers model



What Christaller did within his work was take the concept of agglomeration pioneered by Marshall and relate it to the world he saw around him, i.e. the spatial distribution of cities and towns in Southern Germany McCann (2001). The reasoning for the relative agglomeration of cities is thought to be based around a demand, this is firms operate within the same space so as to access the market. Whilst more contemporary thought such as that of Porter (1998) sees the hierarchal interaction as a value system exercise, specifically, the intermediary service and good providers operating within the same locality as those firms with which they do business. In practice central place theory does fall down, the assumption of isotropic and homogeneous land means no account is taken of natural resource endowments existing unevenly across economic space.

This is a great weakness along with even distribution of rural markets. Shonkwiler (1996) used a statistical analysis in order to demonstrate that retail business inter-dependencies exist and that minimum demand threshold values for retail sectors are sensitive to the presence or absence of other retail firms. Shonkwiler goes further and outlines that using central place theory goes some way to explaining spatial clustering, by pinpointing demographic characteristics, socio-economic structure, potential expenditures, and finally consumption which all play a part in making this occur.

Mushinski and Weiler (2002) used a regression framework to show that supply and demand factors in neighbouring areas affect the geographical inter-dependence of retail businesses. Particularly significant, was the supply side in the retail industry, whereby the authors note that the "outlying establishments tend to reduce the number of establishments in a place which underlines the importance of spatial competition in retail development". The conclusions reached by Christaller were far reaching and during the rest of the 1930's another raft of research focusing on the key demand factor in location theory emerged. In 1940, August Losch published Die Raumliche Ordnung Der Wirtschaft translated into English in 1954 under the title "The Economics of Location". This work was seen by many such as Valavanis (1955) as being as important to economics as Keynes' General Theory. Losch made a distinction from the work that came before, in particular that of Weber, and dismissed the least cost perspective in location choice.

More importantly he also concluded that the area where revenue is greatest does not determine location. What he theorised, is that firms go to where they can maximise profit; i.e. the area where total revenue exceeds total cost by the greatest amount. What resulted in making these assertions, (there being variations in both the demand and costs) created an unsolvable problem. This is because, inter-dependence of firms, the running of one firm may involve the relocation of another. Losch Notes,

> *"If we wish to be precise and to consider the influence of the selection of a particular location on all other locations... then we enter upon the general theory of location. The repercussions, strictly speaking, are transformed into mutual relations, and it ceases to be meaningful to pick out one location and examine its relation to its neighbors in isolation. We are faced with the interdependence of all locations. Equilibrium of the locational system can therefore no longer be charted, but can be represented only by a system of equations that are insoluble in practise". (Losch, 1954, p. 8)*

Losch was giving a warning to regional scientists; his understanding of both theory and reality in equal measure told him that the amount of simplification needed to make the models work was great, and usually involved a one-sided solution to a two sided problem. What the research goes on to do is to realise these variations in economic space in two ways: price funnels and demand cones. Losch assumes a standard downward slopping demand curve as stated in figure 8 (p42).

He considers the demand for beer (OP) being equal to the price of the commodity at the brewery. Those living within that locality i.e. the local market will buy the level (PQ). Price is considered to be directly proportional to the distance, as such the quantity demanded falls the further away from the site of production, therefore at point F there is zero demand for beer. Aggregate sales correspond to the volume of a cone produced by rotating the triangle (PQF) around (PQ) (see figure 9 overleaf).

In this formulation, the market area is given as the circle with the radius p. The supply components such as barley and hops are circles of various sizes around P. If profits rise then new breweries will begin to open in the locality, thus competition pushes the circular markets into equal regular hexagonals. This is similar to the notion conceived in Christaller's work, in particular, Losch reconciles the fact that the market areas are hexagonal as a result of transport costs. What this results in is the disappearance of both brewery profits and beer-less areas. Meaning that as one industry is unable to supply all the potential market, the spaces between these industries attract other producers.

Figure 8. Demand Curve

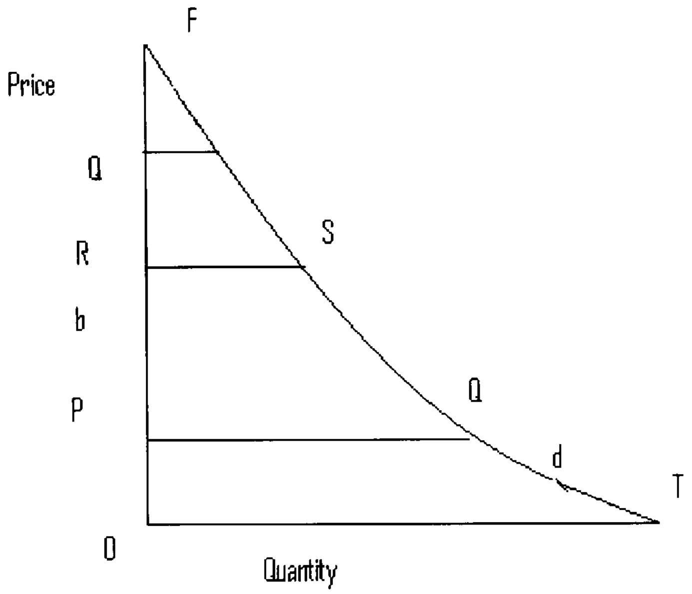
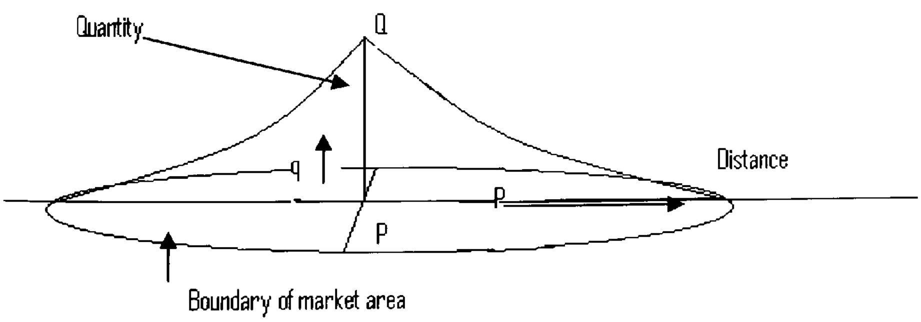


Figure 9. Demand Cone



The hexagons within the model vary in size dependent upon the individual demand for beer, the transport of beer and the intermediary components used in the production. Firms concentrating in one geographical area persist in this model similar to its predecessors. Losch however sees economic space being occupied by more than one good moving away from the Weberian work of the early 1900's.

The optimum distance between consumers and breweries (i.e. the logical place to locate to have the lowest transport costs) may not be the optimum place for other goods such as bread and laundry services. Therefore, populations group together in equally distant spaces each having identical characteristics. In this example having a brewery, bakery and laundry so as to optimise the transport costs for all the goods that maximise the utility of the agents.

What Losch then goes on to include is the interaction between different industries and in particular their relationship to agriculture. What the model predicts is that as different goods start to be produced a complex arrangement of hexagon shaped markets appears for each industry.

When these systems are connected together there will be at least one production centre common to all these industries. He refers to this area as a metropolis. When two or more of these production loci exist, they will form towns or cities. So far there is not a great deal of deviation in the implications of this formulation from that of Christaller's work.

Where the work does deviate, is that Losch attempts to postulate the concentration of towns in a certain part of uniform geographical space, i.e. the individual systems are considered to rotate around the common centre or metropolis. The resulting pattern is one in which six sectors with numerous production sites coincide with another six sectors where there are fewer. Where these coincidences occur in an area the result yields the highest number of purchases made locally. This is simply as a result of the lowest possible transport costs. Losch refers to this geographical arrangement as the economic landscape; he notes that these are distributed around the world like a network. Losch's work is not without criticism and although his model does provide some explanation for the geographical dispersion, in this particular work he sees in Indianapolis other factors which do not support his view.

Greenhut (1956) notes that the only way in which spatial activity will operate as described by Losch is under direct government intervention, and so is of little use in competitive capitalist economies. Further criticism comes from Holland (1976) who explains the severe problems with the number of assumptions made by Losch. Perhaps the greatest criticism that has been dealt to the theory comes from Backham (1956), and Valavanis (1955) among others.

These authors point to the agricultural assumption being a clear weakness. Only certain remote sectors of the economy will have the connections with agriculture as outlined within Losch's framework. This pattern formed by Losch's model is intriguing and what cannot by any means be thought of as a complete theory of location, does offer insights into the location of production activities when looked at from an intra-industry perspective.

Multiple goods being produced within the same spatial parameters follows similar thinking to the Marshallian perspective, by considering this to be a network which extends this concept even further. Although demand cannot solely explain the dispersion of activities its force in encouraging industries to group together should not be underestimated.

Hoover (1948) used the principles of Marshall's work to understand industry agglomeration but also introduced a more detailed typology and emphasised how agglomeration leads to the success of individual firms. What this research importantly conceived, was the implications of multifarious production substitution patterns. Substitution is thought to occur on the input side, the output side and between the individual inputs and outputs. Hoover identified three types of agglomeration: economies of localisation, economies of urbanisation and internal returns to scale. Economies of localisation agree with the framework laid out by Marshall, i.e. same sector based industries are being drawn together by the three "magnetic pools". Economies of urbanisation incorporate a second external factor that is the power of a large diverse market; this has been referred to in some work (McCann (2001)) as being the characteristics of a metropolitan area. Internal returns to scale is when output grows more than proportionally with the quantity of inputs.

These are a result of firm specific factors, which exist within certain localities coming about because of the existence of large and specialised factors of production. The extent to which it is possible to make distinctions between these measures has been called into question in work such as (McCann, (2001)).

With the acknowledgement of the existence of agglomeration authors began to question the effect that this has on firms within close proximity.

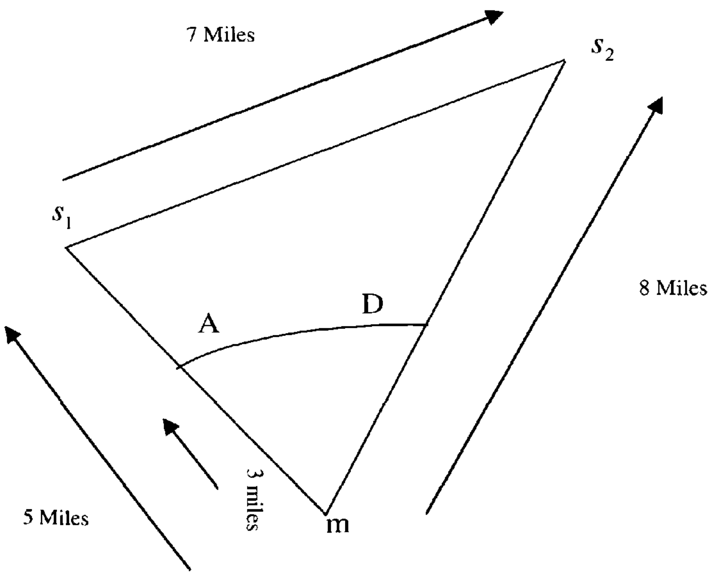
2.5. Unity in Traditional Location Theory

The work so far has set out to explain how the location choice of a firm is made. In 1956 Walter Isard set out to piece together the works of Thünen, Losch and Weber into one inclusive model that would allow the development of a General Location Theory. Two of the models fit easily together: the concentric rings around a central city proposed by Thünen and the hierarchical pattern of settlements and hexagonal areas surround a metropolis conceived by Losch. The incorporation of Weber's work allows the augmentation of the uniform and equal distribution of resources on an even place. This is done by assuming plant location is determined partially by material localisation and allows the possibility that production sites can come about through Weberian mechanisms, which can exist within a Thünen-Losch landscape.

In order to make the theory work effectively, Isard includes other economic theory, primarily in his first work the substitution principle. He is not the first to consider linking this to location theory. Predohl (1928) seems to hypothesise that this can possibly be done but stopped short of empirically deriving it. How it incorporates into the concept is via the choices a firm makes over the expenditure they outlay on the different factors of production in the choice of location.

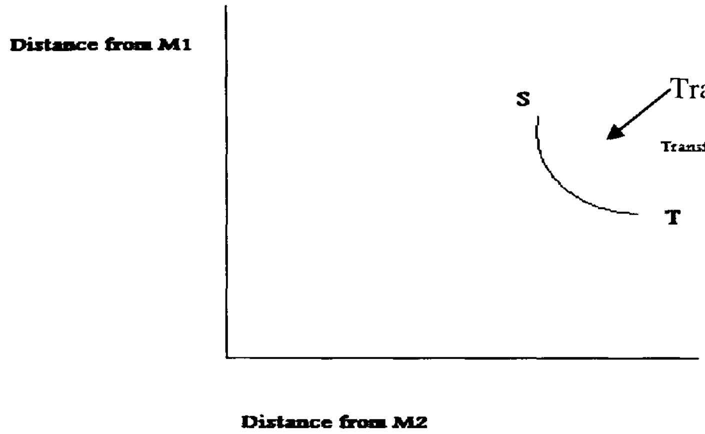
Greenhut (1956) considers this issue and notes that the principle of substitution, whether with regard to capital and land, is the same problem as the selection of plant location anywhere within economic space. Traditional economic thinking would suggest that the problem is solved when the scarce resource is allocated in the most optimum manner. Isard also gave transport, referred to in the earlier works as distance, a prominent role as an input factor. He conceivably argued that it should be thought of on the same level as the traditional factors of production, land, labour, capital, and enterprise. The model that Isard uses (see figure 10) starts with the traditional triangle (Weber 1909), to find the optimum location strict assumption must be made about transport costs and the quantity of raw materials needed by a firm. The traditional Weber model is organised in the same manner as previously discussed, but this time, for the purposes of analytical explanation, dimensions for distances have been included.

Figure 10. Location Triangle with Substitution Framework



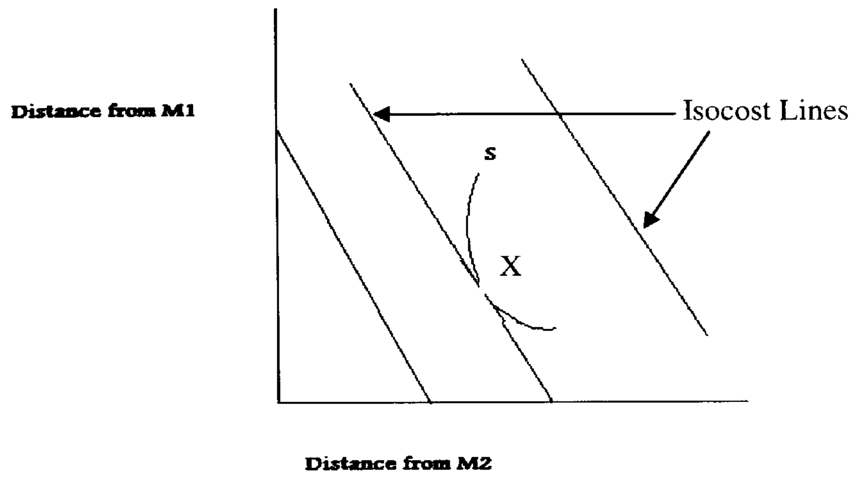
Let us assume that a plant exists three miles from the market. The arc TS represents the loci of possible locations see figure 11.

Figure 11. Isard's Transformational Line



Isard proposes transposing this arc onto a transformation line on a graph where the two axis represent the distances between the two material inputs. If a firm was to move along the transformation line from S to T the inputs from point TM1 become cheaper, this is to say transport inputs are being substituted between the two localities. Figure 12 overleaf shows all the possible costs associated with moving production closer to one of the input sites. These isocost lines have an equilibrium, this is where the curve ST is tangential to the lowest value isocost line.

Figure 12. Isocost Lines in Isard Framework



Isard (1956) took a pioneering approach to the study of location dynamics and described industrial complexes, by referring to the idea that one product is most likely produced by many different activities. This was ground-breaking as it tied the work of Leontief (1941), using input-output tables to give monetary values to the cost of combining a region's industrial activities. Isard's contribution to location theory was best known for his work understanding the mechanisms of agglomeration. Looking at inter-industry linkages combined with the geographical proximity involved, the basis of this analysis was the Launhardt Weber model employing fixed coefficients. The work of the neoclassical growth theory practitioners infiltrated the thinking surrounding location. For example, Perroux (1950, 1988) broke ground on the concept of growth poles, whereby areas where large strong firms create positive economic effects on smaller organisations within the same geographic proximity.

These large firms drive the economic growth of a locality through large-scale expenditure on innovative activities. The inter-sectoral relationship, which exists in these areas, drives the concentration and dispersion of economic activity. What growth pole theory starts to unearth is something of a polarization effect or clustering of industries.

A significant problem associated with what Perroux proposed has been the problem of increasing factor prices. With the specialisation of sectors comes the increase in the cost of the factors of production. This increase in production cost result in higher priced goods. The increasing prices are the result of the demand for local commodities rising; this is explained well by McCann (1997). This "backwash effect" has been noted in the literature and empirical findings in the work of Bell (1973) and Thomas (1975) supports this argument. The other important contribution that Perroux made was in his later work of 1988 when he distinguished the temporal conditions within agglomerations. Perroux identified two distinct phases in growth poles; the first is a cluster phase where firms benefit from close proximity, and the second is growth occurring outside this area as a result of information and investment flows outside the growth pole. This principle has been conceived in modern literature by the term 'cluster life cycle' and has been looked at by authors such as Wolfe and Lucas (2004) and Andersson et al (2004) and will be discussed in more depth in Chapter 5. However in (1957) a different style of work was proposed by Myrdal. Instead of focusing on the stabilisation of market forces, and change being described as a result of exogenous factors, an endogenous view was proposed drawing attention to the circular and cumulative effects present in an economy. Up to this point the location theories examined have at their heart the concept of equilibrium like most economic models of the time.

2.6. The Cumulative Process of Growth and Intuition

Another way of looking at economic processes is to say that they can be viewed as "cumulative because of circular causation" (Myrdal 1963, p152). Cumulative causation theory as it has come to be known does not have an exact date of coming into being. Its origin is open to debate and Fujita (2007) considers the work of five economists being contributable to its creation Young (1928), Kaldor (1970), Veblen (1898), Wicksell (1898) and Myrdal (1957).

One of the underlying concepts seen in all this work was the notion of increasing returns based on Marshall's original thinking. Within a location based approach, Myrdal's work stands out and is seen by many as the unifier within the field. Two distinct features that were introduced in the 1957 work, that allowed the model to work, were backwash and spread effects. Backwash effects are defined as "all relevant adverse changes" (Myrdal 1957, p30). These can come about as a result of trade, migration of labour and the free movement of capital. They are essentially dampening effects on a geographical locality in the short run. The result is inefficiency caused by taking resources away from the concentration of industry.

Spread effects are essentially the opposite; the growth within the centre flows outwards, allowing knowledge as well as capital to diffuse to surrounding areas. The work in some part draws a political meaning. He believed that due to the power of cumulative causation government policies must be used to control natural economic forces. What the work formed was what Myrdal referred to as the core-periphery model.

What is emphasised again within this work, is that capital and labour agglomerate in areas where they can receive the highest return possible and as a result of cumulative causation, these areas will continue to attract more capital and continue to strengthen. Cumulative causation explains how regions which are doing well in terms of economic growth, continue to do so.

The work notes the significance of modern sectors having a competitive advantage in factor endowments and will continue to gain strength over areas considered as being disadvantaged where traditional sectors make up the majority of the economy. The theory also explains how there will be divisions between the industries operating in different areas. Factor endowments in one place will attract certain industries; factor endowments in another will do the same. Due to differing economic practises their effects on the respective locations will be different and so as such, offer different benefits in terms of economic development. The cluster concept has also been linked into this work by Britton (2004). He talks of path dependence, which brings an element of time to clustering. Cumulate causation is considered to bring about innovation and increased investment; these effects cause regional economic systems to form. These systems in turn create clusters or pockets of industry.

As the research agenda changed towards the start of the 1960's, the emphasis moved from micro founded theoretical models to more intuitive based studies. A good example of this shift is Chinitz (1961), which looked at the city structures of New York and Pittsburgh. His focus on location theory was abstract in its form but the basis of his primary findings mark a strong note linking into the literature on agglomeration.

Chinitz postulated a so-called incubator model: the ability that older established cities, with strong trading relationships, have in creating new business start-ups. Diversification among the different levels in the industrial clusters based in the cities, provides solid areas for possible business development by giving access to production factors and having input markets in the same location. The incubator model is interesting at its core, without formally specifying the factors, is the assumption, that city structure conforms to traditional theory. Marshallian dynamics play a part in explaining how the advantages for new businesses come about. The interaction between the old and new industries allows knowledge transfer and labour migration thus reinforcing the strength of economic position of a geographic space.

This strand of the literature was also investigated by Henderson (1974) who emphasised the importance of spillover effects and their power in creating agglomerations. He notes the importance of close proximity in generating these effects. This, as with all Marshallian based thinking, results in regional specialisation, whereby a dispersion of activities take place across geographical space each occupying the optimum location in terms of factor costs.

2.7. Krugman A New Old Theory of Agglomeration

During the late seventies and early eighties international trade and industrial organisation theory proliferated the economic geography literature (Martin and Sunley, 1996). To this end, the work of Paul Krugman has come to the fore, his specialisation on trade theory specifically incorporates a local and regional scale. Krugman himself notes that in order to understand trade you must first understand the concentration of production.

Krugman (1979, 1980, and 1991) was one of the first researchers to dispense with the notion of constant returns and perfect competition.

His goal was to remove the micro obstacles of the past, in forming a new twenty first century location theory. The replacement increasing returns to scale along with a monopolistic market structure, allowed greater variance among the possible alternatives of location. Product heterogeneity and fixed production costs were found to bring about specialisation at the firm level; this in turn explains the presence of monopolistic markets.

The logic behind this is easy to explain: it is cheaper to produce one single product in bulk (economies of scale), rather than a variety of products in smaller numbers. Again, the model introduces transport costs, and like traditional thinking suggests the need of firms to minimize these. The unique element is the terminology and the inferred cost saving that Krugman describes.

Instead of asking the traditional question of why is a particular industry concentrated in a certain location; Krugman considers why manufacturing ends up concentrated in one or few regions of countries. In this formulation, the country is seen as divided into a core centre, where manufacturing and heavy production take place, and a periphery used to supply the, usually dominated by agricultural industries.

The work takes a general approach with the purpose of avoiding industry specific spatial factors and instead examines the external economies that give rise to concentrations. The other important contribution was the assumption, that the externalities that lead to the core periphery structure are the result of pecuniary economies.

Pecuniary externalities were first examined by Scitovsky (1954), when he coined the term to explain the externalities rising from market imperfection seen in both demand and supply. One of the key variables in determining the result of these effects is market size. Large markets allow large numbers of firms to operate without cutting their prices. The resulting effect is increasing market size which brings about increasing returns. The other key pecuniary effect is technological externalities brought about as a result of spillovers from the production activities of one firm onto those of firms operating within close proximity. Krugman goes a step further and emphasises the point, that pecuniary effects are not the result of purely technological spillovers from the proximity of industries, but from the linkages in terms of both supply and demand.

This has a much greater significance than is assumed at first. Within the traditional Marshallian dynamics of perfect competition, pecuniary effects have no welfare changing role. However, they do within the context of imperfect competition assumed by Krugman. Adding to the above assumptions of increasing returns, pecuniary externalities play a prominent role in defining the industrial landscape.

It is safe to conclude that if one firm's actions can have an effect on the demand for a product being produced by another firm, maintaining that the price exceeds the marginal cost, the resulting actions are as Krugman considers it "real" externalities rather than pecuniary. This concentration by Krugman greatly influences the interpretation of Marshall's traditional work, as noted by David and Rosenbloom (1990). In particular, he notes that labour market pooling and availability of non-traded intermediary goods are brought about by the market size effect. Within his 1993 work he also complements the work of Fujita (1989) by using market size effects as a way of explaining urban agglomerations.

What the research does is enforce the relationship between firms, conceiving a cause and effect argument to be formed rather than relying on the external economies to be generated by "invisible" factors. Krugman illustrates his point using a similar style of postulation, to that done before in the work of Christaller (1933) and Losch (1940). A country is thought of as having two types of production: manufacturing and agriculture (the latter characterised by constant returns to scale and immobility in the factor of land). The location of industry within the agricultural sector, is therefore determined by the exogenous distribution of heterogeneity in economic space.

The manufacturing sector can be thought of as having increasing returns along with limited use of the land resource. Assuming economies of scale, it is logical to presume that manufacturing will take place in a limited number of areas. The other determinate of location will be demand, as with all previous work, transport costs are assumed to play a prominent role. As such production will take place close to the market in order to minimise transport costs.

The question therefore becomes a determination of where the greatest demand exists across all economic space of a country. This issue had been considered in other work before namely Harris (1954). His work, noted that the desirability of a location to a manufacturing firm is proportional to its proximity to markets where demand is greatest. Harris proposes a scale based on what he calls the "market potential" index, this is a weighted sum of the purchasing power of all locations, where weights are inversely dependent on distance.

This can be formalised as follows:

$$M_j = \Sigma_k \Upsilon_k g(D_{jk}) \qquad (7)$$

The market potential of a location j is derived from the above, where Υ_k is the income of location k, D is the distance between j and k. The $g(D_{jk})$ is described by Chisholm (1990) as some form of decreasing function. Chisholm quotes Harris's work in detail and notes "Manufacturing has developed partly in areas or regions of largest markets, and in turn the size of the markets has been augmented and other favourable conditions have been developed by the very growth of this industry" (Harris 1954, p. 315 cited by Chisholm 1990).

The common weakness in the work of Chisholm, along with many other traditional location theory specialists is the assumption that the location of demand is limited to one particular sector. The problem is even more simplified in the work of (Christaller, 1933), simply assuming that it is primarily driven by the demand in the agricultural sector. Given this, the traditional lattice patterns appear with industrial manufacturing location being determined by agricultural land.

What Krugman suggests is that as well as the demand from the agricultural sector, demand exists from other manufacturing firms. This supports the notion of cumulative causation proposed by Myrdal (1957) with concentrations of industry being greatest near a large market; conversely the market is largest where manufacturing has the highest concentration.

Krugman in his 1991 work speaks of two forces: centripetal drawing industry together into agglomerations and centrifugal forces that destroy the structures present within agglomerations or as Krugman puts it "limit their size". Krugman's work draws heavily on the Dixit and-Stiglitz (1977) model of monopolistic competition.

Upon first examining Krugman's work , it does not appear clear that increasing returns makes it profitable to produce each variety of goods in only one location; as such you end up with different areas each having differentiated portfolios of products. When new labour enters a location it is not existing firms output that increases it is new products that are produced. This finding closely resembles the intuitive argument given by Chinitz (1961) who spoke of the diversification of industry within cities creating stronger regional growth. It becomes essential next to determine the income at each location, as this is directly proportional to the output of both sectors. Transport cost are assumed as stated previously to only exist for manufacturing and as such it is easier to measure the prices and wages in terms of the agricultural good.

Let there be μ workers and 1-μ farmers. Then the economy as a whole is said to have a workforce equal to 1, this can be summarised as:

$$Y_{j=(1-\mu)}\varphi_j + \mu\lambda_j w_j \tag{8}$$

Having constant elasticities of substitution and assuming the price on arrival from location k, j is given by $w_k \exp\left(\tau D_{jk}\right)$. The true price for manufacturing at j is then expressed as:

$$T_{j=} \left[\Sigma_k \lambda_k \left(w_k e^{\tau D_{jk}}\right)^{1-\sigma}\right] \frac{1}{\sigma-1} \tag{9}$$

∴

The equilibrium wage rate can be solved:

$$w_{j=} \left[\Sigma_k \lambda_k \left(T_k e^{\tau D_{jk}}\right)^{\sigma-1}\right] \frac{1}{\sigma} \tag{10}$$

This however only results in a value in terms of agricultural goods. Workers look for real wages made up of a consumption basket of both manufacturing and agriculture. Wages in location j are then a combination of both these sectors.

$$\omega_j = w_j T_j^{-\mu} \qquad (11)$$

What Krugman was trying to illustrate with these models was the centripetal and centrifugal forces at work. With the formalisation and assumptions holding it is possible to mathematically derive the relationship between these forces. Let us assume that there is the same number of farmers existing across both localities using the notation as before

$(\varphi_1 = \varphi_2 = 0.5)$.

The question posed, is under what condition is the employment in manufacturing concentrated in one locality rather than spread across both? Or$\lambda_1 = 1$ or 0. The occurrence of this situation could explain the forces of attraction and dispersion. These assumptions can be employed to solve the equations (20) and (23) simultaneously. Concentration of manufacturing at location 1 is in equilibrium if$\omega_2 < \omega_1$. Normalisation of the distance between the two locations is employed converting it to 1.

Plugging these values into the original equations finds that$w_1 = T_1 = \omega_1 = 1$ substituting this gives:

$$\omega_2 = \left[\frac{1+\mu}{2} e^{-\tau(\sigma-1)} + \frac{1-\mu}{2} e^{\tau(\sigma-1)}\right]^{1/\sigma} \qquad (12)$$

And

$$\omega_2 = e^{-\tau\mu}\left[\frac{1+\mu}{2}e^{-\tau(\sigma-1)} + \frac{1-\mu}{2}e^{\tau(\sigma-1)}\right]^{1/\sigma} \quad (13)$$

The right hand side of equation when < 1, produces centripetal forces maintaining the concentration of manufacturing. The model Krugman ends up with explains the intuitive arguments seen throughout the work of the last century: Circular relationships between the market location and the location of manufacturing create agglomeration of industries. This can now be examined with the use of the model, assuming manufacturing represents a very small component of the economy or $\mu \approx 0$ (25) will reduce to:

$$\omega_2 = \left[\frac{1}{2}e^{-\tau(\sigma-1)} + \frac{1}{2}e^{\tau(\sigma-1)}\right]^{\frac{1}{\sigma}} < 1 \quad (14)$$

The resulting finding is always less than 1 because of Jensen's inequality. In this example, the only sales are to the agricultural sector, as a result dispersion of manufacturing industries is likely, in order to avoid competition, this is proof of a centrifugal force. If we consider again equation (13) when manufacturing is a significant part of the economy, the first term in the equation becomes greater than 1. This is due to (11), or manufacturing firms existing as suppliers to other manufacturing sectors within the same location. This mathematical finding supports the intuitive argument of Hirshman (1958) who speaks of forward linkages in terms of intra industry trading relationships between firms.

The result of the findings also implies that the location where manufacturing is concentrated has a higher income than other areas. This supports the notion of backward linkages also existing, where manufacturing industry wants to be close to the self perpetuated market.

2.8. A New Theory of Location or Confusion?

What Krugman did was give solid mathematical weight to the arguments perpetuated over the century before. In doing so, many authors such as Baldwin (1994) concede that Krugman has created a new location theory, however, the work is not without criticism. Knox and Agnew (1994) argue that the core periphery model being constructed in Krugman's work does not follow the rational location based models of the past, which derive a long term process resulting in convergence.

They go as far as to say "the long run never arrives". They point to there being multiple equilibria which exist for considerable periods of time but can be reshaped by new concentrations of manufacturing at any time. The main issue they seem to raise is the static nature of the analysis; they identify the lack of dynamics in the forces of increasing returns, and imperfect completion over time. Krugman raised another major issue himself in his 1991 work on geography and trade. He notes that the patterns of concentration only exist within certain industries, but he promotes the notion that the same forces that explained the growth of nineteenth century industry still play a part in forming agglomerations today.

This, as Martin and Sunley (1996) point out, is a possible reason why Krugman places little credence on technology spillovers as a reason for clusters today. On this note, these authors draw a division between this work on geographical economics, taking a historical perspective, and the new industrial geography literature emerging over the last decade. This point is interesting and raises many concerns over the division in the current thinking within regional agglomeration theorisation. Scott and Storper (1992) question how important internal economies of scale and scope are, in the presence of increased market uncertainty and rapid technical change. The result has been, according to Storper and Walker (1989), decreased one site production and as they perceive it to be horizontal and vertical disintegration.

This work implies that agglomerations in economic space have been of a highly specialist nature Sabel (1989), in what the author refers to as industrial districts. This is a clear distinction between the traditional view formalised by Krugman and the post Fordist approach conceived by Scott and Stroper (1992).

A comparison of the two sets of thinking is shown in table 3 overleaf based upon the work of Martin and Sunley (1996).

Table 3. Krugman's work Vs the New Industrial Geography

	Krugman	New Industrial Geography
Externalities	Marshallian (Labour pooling, specialist suppliers) "Pecuniary" effects	Marshallian effects, Labour market, Specialist suppliers, Technology and Knowledge spillovers
Agglomeration	Local Clusters, Interregional centre-periphery pattern	Industrial districts, Craft based, High-tech, Financial centres
Competition	Imperfect: Monopolistic, Economies of scale	Competitive flexible specialisation, Economies of scope
Transfer Costs	Transport, Trade Barriers	Transactions costs
Technology Spillovers	Not typical, Important in some industries	Local and fundamental to success in high tech clusters
Labour Market Pooling	Strategy of insurance against risk	Form of local social embeddedness
Social and Cultural dimensions of clusters	Difficult to formalize	Key preconditions for successful Localisation

Some stark differences emerge between these two schools of thought, in particular the social aspect appears to have little if any effect on agglomeration in the traditional work of Krugman, whereas within the new industrial geography it is seen as a vital mechanism that holds agglomeration in place. However Scott et al (1992) view of agglomeration is not without criticism. Lovering (1990) as well as Phelps (1992) questions if uncertainty within an industry forces firms to behave in this manner. The primary focus of the attack is on the assumption of perfect competition. The situations which Scott describes in his models on agglomeration are based on perfectly competitive situations ignoring the power that linkages with other firms have. This view is also supported by the work of Markusen (1993) who comments on the competition between multinational firms who compete all over the world with firms of a similar size. The number of players in the market is low but the power or influence they maintain varies greatly, which indicates this has the characteristics of an oligopoly rather than a perfectly competitive industry.

Krugman's work has changed the field of regional economics and has laid the path for future research, although as can be seen from the criticism above, is not a complete description of agglomeration. New industrial geography literature provides a strong argument for the spillover effects, in fact, authors such as Phelps (1992) would argue that it is these forces which create agglomerations.

Traditional theory has been altered with the work of the neoclassical modellers Alonso (1964), Muth (1969) and Evans (1973) trying to incorporate greater substitutability into the original models of Thünen and Weber.

However, the results have been mixed and work by McCann and Sheppard (2003) seriously questions how far these works have gone in explaining the grouping of economic activities in geographical space. Marshallian economics should not be over-looked and in particular Marshall's three forces come into play in a great deal of the work before and after its conception.

The Marshallian theory remains an important component of the new geographical literature. An exploratory paper by Phelps (2004) talks of the notion of borrowed space and Neo-Marshallian externalities. Phelps takes a step back from the heavily researched inter-firm linkage perspective considered in Berman and Feser (1999), Hill and Brennan (2000) and Feser and Lugar (2002), instead focused on externalities of labour market pooling and technological innovation. What the work cites, is the idea that externalities are no longer (and may never have been) hard to come across, noting the problem is believing that these only exist in self-contained places. He further argues that the diffusion of these externalities across economic space has meant that intermediate locations, areas such as suburbs and edge cities can offer forces to attract business.

This works due to the notion of borrowed space Alonso (1973). According to Alonso one area starts to take on the characteristics of another area of a larger size due to its proximity to one another. This is flouting the traditional Losch and Christaller models of hierarchal cities, whereby perceived boundaries exist between areas of different characteristics.

Phelps concurs that Krugman's work is important, suggesting it is the relationship between pecuniary and technological externalities which offer understanding into today's "spatially diffuse" agglomerations. McCann (1995) raises the point that this perception should make regional economists and geographers alike, question the value of the current definitions of external economies.

Numerous other authors have contributed to the development of this field: Hotelling, Venables, Palander, and Greenhut to name but a few. However, what this work has tried to bring together are the convergences and divergences over the course of the last 150 years of research. The new economic geography has been emerging for a considerable period of time through the contributions of Masahisa, Fujita and Jacques Thisse, but to what extent is a new economic geography? Similar patterns appear to have been in existence since the initial work of Thünen in 1826. In recent years, authors have written numerous empirically rigorous analysis of regional economic geography, which has focused on strong micro foundations, although their treatment of industrial location theory with relation to economic clusters has been over simplified.

2.9. Conclusions

Patterns within all of the work suggest that industries to a greater or lesser extent tend to occupy the same area of economic space, (with relation to the positive effects the work is slightly weaker). Economic growth and the phenomenon have only been considered to a very small extent by authors such as Myrdal.

Theories have evolved and meanings have been rewritten but some factors remain mystified and complex. The location choice of firms; certainly within traditional theory Thünen, Weber, and Losch, is certainly dominated by transport costs and the proximity to markets therefore a trade off could be seen to exist between economies of scale and transportation costs. An important issue that questions this in today's modern world persists: Within an era of dynamic global factor mobility can transport costs really dominate the location choice of firms?

A more profound point that can be raised, concerns the underlying concept of agglomeration or clustering. Since its early mentions in the work of Marshall to the new modelling of Krugman (1991), very little emphasis has pertained to the forms of interaction other than trading relationships, nor does the historical work address the nature of firm dynamics in terms of industrial make- up within agglomerations. This chapter started by noting where the current thinking within regional economics is today. This chapter however ends by questioning whether the models of the past have been formalised to a point where the intuitive meanings sought by the authors are lost in a haze of empirical rationality. The notion of agglomeration is grounded in mathematical formulation. The work in this chapter, however, has not considered its intuitive implications.

Agglomeration has been tackled from a more intuitive point of view in other literature, however. It is therfore now essential that these contributions to the field are examined in depth. This is what the next chapter focuses upon, as the literature attached to the concepts of what has become known as clustering, are considered.

Chapter 3: Economic Clusters

3.1. Introduction

The previous chapter of this work focused on the classical theoretical work surrounding location theory and the notion of industrial agglomeration. This chapter will however focus on a different aspect of the literature: one which has seen a remarkable growth over the last 17 years. Traditional writing in economics took a very theoretical construct approach to explain why firms exist in the locations they choose to. The supposed conclusions could provide one with an idea of the benefits to organisations of operating within close proximity. However, a piece of work in the 1980's changed the research agenda and brought the notion of an agglomeration to a much wider audience, by using the more simplistic term, a cluster.

3.2. Porterian Clusters

Michael Porter has written in detail about clusters from many different perspectives both from an economic and strategic perspective. His work draws on the field of globalisation and investigates the transition from the fixed factors of production seen in the past to the shrinking virtual markets of the twenty first century. However, he maintains that location is still one of the cornerstones in attaining competitive advantage over other organisations, and can be seen clearly in his 1998 "Clusters and the new economic geography" publication. He considers today's world economy and comments that it is dominated by clusters and in addition goes on to clarify that these are "Critical masses in one place of unusual competitive success in particular fields".

Porter's definition of a cluster has been taken on board by huge numbers of researchers and has been cited across many different strata's of the field. Porter defines clusters as:

> *" .. geographical concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition. They include for example, suppliers of specialized inputs such as components, machinery and services, and providers of specialized infrastructure. Clusters also often extend downstream to channels and customers and laterally to manufacturers of complementary products and to companies in industries related to skills, technologies or common inputs. Finally, many clusters include governmental and other institutions- such as universities, standard setting agencies, think tanks, vocational training providers, and trade association that provide specialized training, education, information, research, and technical support."*

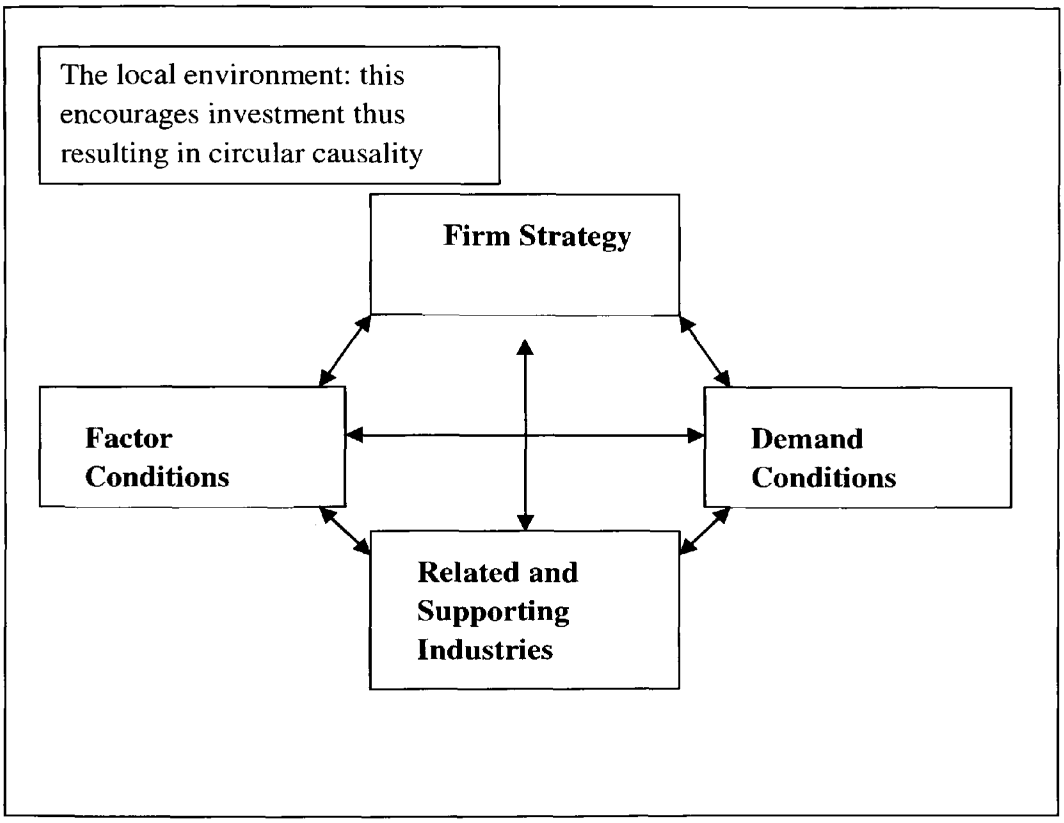
This all purpose definition is designed to point to specific characteristics inherent within clusters whatever industry they belong to. What differentiates his theorisation from a lot of what came before, is the link between clusters and economic competition. Porter conceives that clusters allow those firms which cluster together to compete to a greater extent than those on their own.

He goes further and says that this in turn provides a solid base for both the region and the country in which it operates in, and consequently will allow the country to compete internationally. Porter describes what he perceives allows this cluster to be competitive by three factors. Firstly, he sees productivity being higher from firms within clusters than those outside of them; a concept which goes back to the traditional view seen in the work of Marshall with his three agglomeration forces. The work of Baldwin (2007) also finds significant evidence to support this notion, based upon firm level research conducted in Canada. The second, is that the pace of innovation that takes place within a cluster is significantly greater than single entity research occurring by lone firms. This has been considered by many authors such as Acs and Audretsch (1990), Baldwin and Gorecji (1991), and Baptista and Swann (1998). There is mixed evidence when considered across multiple industrial sectors but overall there is support for the notion of spatial proximity being a major driver of innovative capacity amongst firms. The final major driving force of competition considered and found by Porter (1998), is the stimulation of new firm formation that takes place within clusters. The work of Helfat and Lieberman, (2002) as well as Dahl et al (2003) gave empirical evidence that high geographical concentration within a sector results in the greater growth in the number of firms in that industry. These strong notions of economic growth and prosperity envisaged within this work are what has sparked the rush for further research on cluster existence and cluster development.

Porter's whole cluster analysis began earlier than this work with the initial goal of trying to explore the lack of competition between US firms compared to their Japanese counterparts during the 1980's. This is cited by Martin and Sunley (2003) as being a major driving force for the conception of the work.

Porter in his 1985 Competitiveness of Nations formed what he referred to as the diamond model. The model notes that four sets of factors determine the exporting success of a firm, which can be summarised in Figure 13.

Figure 13. Adapted from Porter (1998).



Adapted from Porter (1998) Chapter 10.

The intensity of the interaction between these factors is what makes a firm more competitive. He found that this interaction increased when firms were located in close proximity. A summary of these factors is listed as follows.

Firm Strategy

The business environment is considered to be dynamic in nature. The high competition results in productivity and innovation.

Factor Conditions

These are the input commodities, such as the traditional factors of production land, labour and capital. Porter also includes local infrastructure, as well as specialist local information and specialist commodities not available in other localities.

Demand Conditions

Local consumers have highly specific needs. These are specialist demands unable to be met in the same way anywhere else.

Related and Supporting Industries

Spatial proximity of upstream or downstream industries aids in the exchange of information, resulting in a continuous exchange of ideas and innovations which result in a greater performance for all firms.

Martin and Sunley (2003) as a result of Porter's finding, conclude that the nation's most competitive industries will be clustered together.

Porters' thinking is far from unique and has been examined by economic geographers for a considerable period of time but with little attention drawn from the policy arena. Martin and Sunley (2003) note this is a significant fact, and raise the idea that perhaps the political agenda influenced the way in which Porter conceived his work, i.e. instead of focusing on the description of what exists in the global economy, Porter set about questioning what can be created artificially. It must be noted that the work has been seen by some as a generic and transmissible policy tool, something which can be used in any region where neo-liberal deregulation, or reregulation processes exist Peck and Tickell (2002).

3.3. Criticism of Porter

Criticism of Porter's work is rife within the literature, in particular, the term "Brand" of cluster is used to describe the research by authors such as Benneworth and Henry (2004). This refers to the notion that instead of a model, Porter is referring to a collection of ideas that came together to explain how firms in clusters compete. Martin and Sunley (2003) take this concept onboard and offer an in-depth critique of cluster theory, questioning whether it is possible to theorise about clusters. They note that a great deal of the work in the field has been done badly with a distinct methodological naivety. The criticism of Porter's work is summed up by the authors:

> *"Why is it that Porter's notion of "clusters" has gate crashed the economic policy arena when the work of economic geographers on industrial localisation, spatial agglomeration of economic activity, and the growing salience of regions in the global economy has been largely ignored"*

What Martin and Sunley are referring to, is the extensive research which links clustering to regional economic development. Work such as Boekholt and Thuriaux (1999), or Cooke and Morgan (1998), link the restructuring of traditional manufacturing basis to incorporate the interaction of industries in close proximity. Other major organisations, such as the World Bank and the OECD, have also focused their attentions on clustering. In particular, on developing innovation systems, whereby new ideas are allowed to spread through firms within developing regions by way of extensive communications expansion as well as increased development of social infrastructure.

Another more critical view of Porter's cluster model comes from Niosi and Zhegu (2005). After conducting a detailed qualitative analysis of multiple clusters encompassing a number of different industries, they came to the conclusion that Porter's theory and in particular his diamond model, is unworkable within most observable clusters. They found that dynamic factors in the framework did not match up to the reality of the clusters they observed. In the aerospace industry, for example, there is little if any inter-firm competition, nor local demand. Instead anchor firms, large organisations within an area, hold all the other firms in place through some form of supply chain relationship.

This rather specific criticism starts to introduce the problems within cluster studies today. Although Porter may have been the first mainstream economist to tackle this issue and bring it into the twenty first century, he is not alone in his endeavours into understanding their behaviour.

The rest of this chapter will proceed as follows: an outline of the numerous cluster definitions will be analysed aiming to infer any possible common characteristics. This will be followed by a critical appraisal of the perceived nature and benefits of clusters and the final section will focus on identification and measurement techniques.

The Porterian definition of a cluster has been a starting point for a great deal of literature but far from being seen as the epitome of the cluster debate, it has spawned numerous researchers to also investigate what these phenomenon are thought to be. The depth which they have looked at the topic has varied greatly and this in itself provides an idea to how the subject has developed so many different interpretations of the same subject matter.

3.4. Cluster Definitions

It is noted by Vom Hofe and Chen (2004) that there is a volume of literature focusing on cluster studies, with a huge amount of similarity in the definitions employed but diversity in the notion of the cluster concept, i.e. the idea of not just a definition but the way in which clusters are explained. They go on to say that most theories and definitions have their origin in traditional agglomeration theory. The interesting point that is made, is that the diversity in itself is self perpetuating; with different definitions comes the need to identify different aspects of agglomeration and as such, new methods are required.

Alfred Marshall in his seminal work referred to these agglomerations or clusters as industrial districts. This was further used as a description in the twentieth century by Becattini (1992) and an industrial district is defined by Wolfe (2004) as

> *"A geographical concentrated production system that is created through a division of labour between several small, specialized business"*

This description is interesting as it offers an insight into a specific component of cluster theory, one area simply being specialist production centres. This would imply a cluster is dedicated to the production of a particular good, as the labour which is pooled within this area is trained for a single purpose. The other interesting point to note is the mention of firm size.

Firm size is a contentious issue in cluster analysis and there is very mixed views on precisely the importance of size in the operation of clusters. Sforzi (1990) suggested that to identify industrial districts one must consider specialisation of firms, which he sees as being characterised by manufacturing businesses employing less than 250 people. However, this is contrary to the understanding of how other clusters operate. Anecdotal evidence from the United Nations Industrial Development Organisation (UNIDO) reports on Emilia Romagne in Italy, where it describes the tile manufacturing cluster which is dominated by larger than average firms. It also outlines the Capri manufacturing cluster which originated as a result of large firms opening within the region.

Feldman and Florida (1994) go a step further and suggest that clusters in some industries are successful based upon the existence of large well established firms. They support this view by implying that small to medium size enterprises (SMEs) within high tech industries engage in technology transfer and in some cases, large firms create spin off enterprises. Other studies such as Rosenfeld (1997) also define a cluster by introducing the idea of firm size specifications, he says:

> *"A cluster is very simply used to represent concentrations of firms that are able to produce synergy because of their geographical proximity and interdependence, even though their scale of employment may not be pronounced or prominent."*

It is important to highlight the interdependence element referred to here. Whether a firm is dependent on the cluster or whether the cluster is dependent on the firm is a chicken and egg style question. A cluster cannot exist without the firm but a firm can without a cluster, therefore the degree to which one can operate on its own successfully is important to consider. If this was the case, there would be an argument to whether all firms need to be in a cluster. It is also referred to by Van den Berg et al (2001) who link this concept with that of the value chain.

The importance of spatial proximity within clusters also comes into the work of Baptista and Swann (1998). When noting the complexities for identification they define a cluster as:

> *"A strong collection of related companies located in a small geographical area, sometimes centred on a strong part of a country's science base"*

The reasons for this choice of definition are numerous. Firstly and most importantly, the work investigates innovative behaviour of companies and secondly it also emphasises the mechanism that Porter sees as existing in a cluster namely; the interchange in information. Another definition of a cluster appeared in the literature focusing on the innovative capacity of these areas.

Aydalot (1984) refers to them as innovative millieux, he defines them as:

> *"Geographical concentrations of firms and supporting organizations that trust one another and frequently exchange knowledge"*

A large number of the definitions which have been considered above all have a similar characteristic and i.e. a static nature. However, authors such as Cooke et al (2002) talk of the dynamic character of clusters and as a result he defines them as, *"Geographically proximate firms in vertical and horizontal relationships, involving a localised enterprise support infrastructure with a shared development vision for business growth, based on competition and co-operation in a specific market field"*

What Cooke et al maintains with this definition is the supply chain nature of clustering. They propagate the idea that clusters have up and down stream industries occupying economic space, in order to reduce the transaction costs associated with a larger proximity between intermediary suppliers. This definition also sits well with the work of Roelandt and den Hertag (1999), that instead of merely defining a cluster, set out the associated characteristics:

"Clusters can be characterised as networks of producers of strongly interdependent firms (including specialised suppliers) linked each to other in a value-adding production chain."

What these definitions seem to lead the reader to glean is that clusters are not some highly complicated process where complex interaction between firms allow them to gain a strong competitive position. In fact they are simply where firms operating within the same economic space often up or downstream, come together in order to benefit from close proximity to one another.

This very general description does not however explain the precise nature of the interaction and the levels to which these interactions bring about competitive advantage. This area of the literature becomes fragmented and begins to borrow from others fields including particular, the work of social network practitioners.

The inherent social nature associated with this description is an important aspect of the theory often overlooked in some of the highly complex empirical work of authors such as Mori et al (2005). However, much research has been conducted linking the virtues of social capital into the dynamics of economic clusters (Hickton and Padmore in Wolfe and Lucas (2004)). These knowledge exchange processes spark a great deal of interest in the literature, indeed empirical evidence supports the notion that clustering is an important prerequisite of innovation (Baptista and Swann (1998), Breschi (2001)). As well as existing firms benefiting, there is evidence to suggest that these innovative processes actually create what are termed knowledge spillovers. These spillovers encourage and foster the development of other firms.

This is supported by Henderson (2003) who finds a positive link between firm births and the strength of cluster activity. Spillovers have been considered a key dynamic in many cluster studies (Feldman, 1994).

Further work looks at knowledge and community structures (Hakanson, 2005). This work encourages policy makers to see clusters as not just concentrations of industry but concentrations of individuals. Moreover this is supported by the work of Loasby (1998) who talks of agglomerations of professionals who belong to similar epistemic communities.

Markusan (1999) argues that if we simply look at a cluster as an economic system we fail to recognise the casual links between the spatially linked activities. The nature of casual links is important to understand, as it bears close resemblance to the idea of tacit knowledge or localized knowledge. This sort of information is important but cannot be articulated easily (Cowan, et al 2000).

Close proximity is thought by some authors to aid in its flow, by giving firms privileged access to information not available anywhere else Hakanson (2005). A great deal of the innovation literature surrounding clusters talks of positive feedback processes (Baptista and Swann, 1998)

During the 1970's, the term industrial complex was used in the literature, based on the Weberian idea of cost minimisation. It is interesting to see, as the forces of globalisation began to gather pace during the 1970's, this definition began to lose favour. Global production systems meant that cost minimisation was not done by locating within another area of the same country, but within another part of the world. Hamilton and Linge (1979) coined the term 'industrial system analysis', which looked at the connected components of specific areas of production. In De Propris (2005) work, she refers to the label of local production systems, as "Geographical agglomeration of firms specialised in one or a few complementary sectors. Such production systems are characterised by an external division of labour, more or less developed social capital and a more or less engaged institutional framework." The definition bears similarities to Porter, but moves away from the supply chain notion conceived within his original definition; this allows a greater flexibility in the type of linkages thought to exist in clusters.

Markusen in her (1994) work formed a typology, that instead of trying to create an all encompassing definition she embraced the diversity present within the field of clusters. She saw four differing forms of industrial cluster with unique characteristics and more interestingly different levels of interdependency and employment. Table 4 contrasts these.

Table 4. Markusen Typology

Type of Cluster	**Characteristics**	**Interdependencies**	**Employment**
Marshallian	SME sized, Locally owned	Substantial interfirm activity	Dependent on synergies
Hub and Spoke	Some large with numerous smaller suppliers	Links between small and large firmly controlled by the large	Dependent on large firm prospects
Satellite Platform	Medium and large branch plants	Minimum interfirm trade and networking	Dependent on branch plants
State - anchored	Large public and non profit firms present	Limited to contact between public entity and suppliers	Dependent on regions expansion capacity

This typology draws together a lot of the research considered before but using the information with a different agenda. The work attempted to not merely put a name to these occurrences but understand the working mechanisms of a cluster.

It must be noted, that what Markusen emphasised was the notion that these were all forms of industrial district rather than using the terminology cluster or agglomeration and some may feel that to this end there is room for movement. The use of firm size as a denominator or a determinant of cluster form, however begs the question over the forms of relationship present within an agglomeration of industries.

The dependency element implies some firms will only succeed through their interaction with others in close proximity. Conversely, for those firms capable of existing outside of a cluster, some benefits must be unique to the spatial locality which encourages them to stay. Markusen's work is an inductive exercise, which focuses on structures rather than processes. The inclusion of certain size firms is thought to trigger agglomeration forces rather than the idea that the processes could exist between any set of participants in the cluster.

Another interpretation of the clustering is summarised in the work of Brown (2000). The work set out to study the dynamics of industrial clusters in Scotland and in doing so focused the definitions of the phenomenon on their individual workings. This is not a new approach to classifying clusters and authors such as Roelandt and den Hertog (1999) as well as Rosenfeld (1995) have taken a similar approach to analysing them. In fact, the definitions complied by Brown are based upon the work of Bergman and Feser (1999), which are similar to the work of their predecessors, namely Markusen (1994). In this framework, there are six types of clusters from a simple geographical perspective all the way up to a self reinforcing complex system. Table 4 overleaf summarises the types of clusters, along with their underlying characteristics. This list is interesting as its inclusion of the term 'business network' is possibly slightly disconcerting for the academic within this field.

Table 5. Brown/ Bergman and Feser (1999)

Form of Cluster	*Characteristics*
Regional Industrial Cluster	A cluster whose elements share a common regional location, where region is defined as a metropolitan area, labour market, or other functional economic unit.
Potential Industrial Cluster	Related and supporting businesses and institutions, that with support could form inter-firm relationships, or critical linking sectors, would obtain some pre-defined critical mass.
Value-Chain Industrial Cluster	A Cluster constructed around an extended input-output chain. It includes final market producers, as well as intermediary suppliers they directly and indirectly engage in trade. Have multiple sectors or industries.
Business Network	'A group of firms with restricted membership and specific, and often contractual, business objectives likely to result in mutual financial gains. The members of a network choose each other, for a variety of reasons; they agree explicitly to cooperate in some way and to depend on each other to some extent. Networks develop more readily within clusters, particularly where multiple business transactions have created familiarity and built trust (Rosenfeld 1995a, p. 13).' Networks are typically more formal than in clusters.
Italian Industrial District	Geographically concentrated firms that work directly or indirectly for the same end market. They share values and knowledge resulting in the creation of a cultural environment. Linkages are a complex mix of competition and cooperation between firms, a result of a close intertwining of economic, social, and community relations.
Innovative Milieux	Not a collection of firms or even a region, but a complex which creates a synergetic process made up of firms which have interdependencies, economic as well as technological. These individual firms create a coherent whole in which a territorial production system and protagonists are linked.

The interconnecting relationship between firms is often described as a network. Yet, authors such as Neck et al (2004) as well as Witt (2004) link the concept of a network with that of a cluster. Pickernell et al (2007), believe this is possibly because of the overlaps in the literature, but as they go on to further note, there are also substantial differences in the definitions of a network let alone that of a cluster. Other work which includes networks as a form of cluster is the deductive approach taken by Gordon and McCann (2000). The work attempts to calm the already raging debate in the cluster literature, by ignoring the ambiguity over the precise structures in clusters and instead focuses on the processes which are the foundations of spatial concentrations of industry. In particular, the work seeks to identify the scale of difference in the existence of linkages within different concentrations of industry. The authors identify three models of clustering; two of which have origins within the traditional neo classical economic theories of agglomeration and the industrial complex style of thinking. The third model, offers a very different approach not often seen within the pure economic theory based literature, focusing on the sociological perspective and linking the idea of networked societies based upon the work of Granovetter (1992) into the cluster debate.

The first model of pure agglomeration takes its roots from the now well established work of Weber (1909) and the earlier work of Thuen (1826). They both highlight the importance of the traditional Marshallian argument and cite the work of Simpson (1992) who examined labour-market effects In addition, Arrow (1962) also acknowledged the transfer of skills in areas where human capital accumulates. Under the category of what Marshall called 'non traded inputs' they consider the work of Scitovsky (1954) who examined local pecuniary externalities and how it links with the notion of inter firm rivalry explained by Porter (1990).

Under Marshall's final category: the existence of local external economies, there is a great deal of academic research that supports its existence. For instance, (Jaffe et al (1993)) examined informal communication links between firms creating so called 'knowledge spillovers'. Gordon and McCann continued by bringing together all the modern arguments that support the Marshallian notion of agglomeration, resulting in a collection of concepts which all come together under the heading of agglomeration. There are of course cautionary words expressed in the piece, in particular a comment from the work of Cantwell (1991) who includes the idea of a cultural dimension, highlighting the differences in interaction between firms of different origins. The resulting model is very general in makeup and the authors' emphasise the demands they put on the work are not that great, making certain assumptions such as little co-operation between firms other than that which is in their own self interest. They also note the fluid nature of this form of agglomeration, constantly explaining the lack of loyalty among firms and also the lack of formal structures which would demand long term relationships.

In light of this, they describe this form of agglomeration as what they call 'open membership', meaning any firm in the local area can join this grouping as long as they are willing to pay the market rent, usually greater than in the surrounding economic space. The authors point to this as evidence of inherent local advantages or spatial externalities. Firms pay this extra charge believing that the interaction between the other firms will bring about increased profitability and so offset the increased rents of locating beside other firms. This model is greatly akin to the work of Fujita et al (2000) and is one of the cornerstones of the so called 'new economic geography' literature.

The second model is again based on the traditional economic thinking whereby, the industrial complex model differs from pure agglomeration as it maintains the existence of stable continuing interactions among firms. The primary interaction between firms is simply trading relationships. This form of cluster would imply a certain homogeneity in the products being manufactured in a locality as the input requirements of firms will create specialisation along geographical lines. The input output nature of these agglomerations is supported by the work of Isard (1949). The dynamics of this model unlike the previous work are very simple. Clusters exist for firms to reduce spatial transaction costs meaning, members location is determined by the strategic links which exist between firms. The model is noted by Gordon and McCann (2000) as being static. This model is stylised interpretation of reality and this poses a problem. The cluster debate as noted by the authors has become disjointed with many interpretations of what a cluster actually is, yet producing a so called best fit model (as noted by Martin and Sunley (2003)) is highly problematic and can result in more complexity and little clarity.

The final cluster type is referred to as the social network model. The development of this perspective is noted as coming from the work of Gravnovetter (1992) based on the earlier work of Williamson (1985). Traditional thinking implies the interaction of firms is based upon the Coasarian thought of transaction costs, whereby firms internalise the production to reduce costs. By completing a task internally, Gordon and McCann (2000) note that trust becomes institutionalised. The social perspective model implies that the given boundaries of firms no longer exist when trust is present, as firms will deal with those who they can work with inside or outside the firm. This means that firms working together and exchanging knowledge are more inclined to take bigger risks in their dealings.

These relationships develop into vast networks, whereby businesses exist as part of an interlocked framework of firms. This model shares similarities with the work of Piore and Sabel (1984) and Scott (1988). The interesting point of social network relationships is that distance and in particular, spatial proximity is not as important as with the other models considered. Some authors infer that these processes are aspatial but McCann and Sheppard (2003) note that trust can be fostered to a greater extent when proximity between actors is reduced. These form of clusters are characterised by Joint ventures.

Keroack et al (2004) in Wolfe et al (2004) take the network argument to another level by introducing their role in the functioning of a cluster. They refer to studies such as Maillat (1995), Porter (1998) as well as Rosenfeld (2002), who speak about the importance of knowledge and describe the benefits of clusters as being the creation and diffusion of knowledge to firms allowing them to become more competitive. The importance of knowledge is not questioned and high profile research such as that undertaken by the OECD (1997) reinforces knowledge creation in the process of economic development. Networks are perceived to be the conduits through which this knowledge flows (Keroack et al (2004) in Wolfe et al (2004)). This is supported by the work of Dicken et al (1994) who use the concept of "learning by doing", or geographical proximity inherent within clusters results in new knowledge creation due to the formal and informal networks that exist between firms. Nevertheless, this in turn is not a new argument if we take it from an individual perspective rather than a firm perspective for a moment. Sociologists such as Romijn and Albaladejo (2002) have shown that closer proximity allows the creation of stronger relationships.

This however implies a major assumption that the best form of network relationship is face to face interaction. Recent work by McCann (2007) casts new light on this subject and calls into question whether this is always the case. McCann's work draws a new model of face to face interaction particularly focusing on the importance to firm location. He finds that there is not always the need for this form of contact and in particular points to the possible lack of importance both within certain industries and also with the age of an industry. The findings are consistent with the traditional product life cycle model such as Duranton & Puga (2001), whereby goods in the mature phase of the product life cycle will be further away from the expensive core knowledge locations. Authors such as Kloosterman and Lambregts (2001) further examine the impact of economic clustering in urban regions, yet with a backdrop of globalisation, the authors point to the presence of local clusters aiding in the competitive process of a region.

Moreover, they note the new technologies that exist in speeding up information processes as well as in developing new products such as the internet should theoretically diminish the role of spatial proximity. The work goes on to identify that many industries have shown strong tendencies to cluster together, citing the work of Krugman (1991), Quigley (1998), as well as Scott (1998) as examples of this. Consequently they establish a rational for cluster formation based upon a large scale literature review. The results of this research lead the authors to the conclusion that so called 'localisation economies,' generated by firms within the same industry locating in close proximity enables economies of scale to be employed. The research goes on to show that in the region of study (Randstad, Holland), these clusters are leading to a clear convergence amongst new start up companies.

3.5. Cluster Dynamics

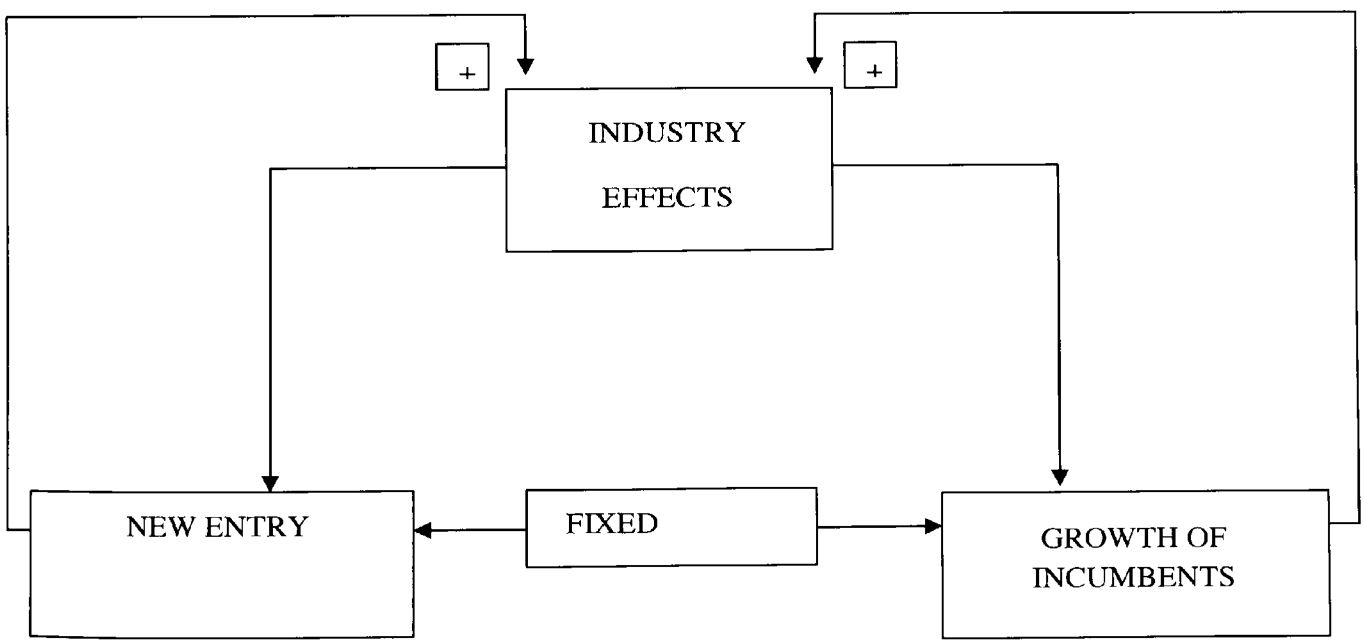
Whether it is networks or the traditional Marshallian view of a cluster the work above demonstrates the continuing ambiguity that exists within the field to date. It is therefore important for a moment, to focus on the workings of a cluster. Work such as Kloosterman et al (2001) as well as Niosi and Zhegu (2005) have firmly put the workings of clusters at the heart of constructing a typology. This research wants to put aside the notion of creating definitions for now, and instead concentrates on understanding what is going on in areas which are said to possess a cluster. In order to do this, the work of Swann et al (1998) has been considered, and the element of positive feedback incorporated into the notion of cluster dynamics. Swann argued that the existence of a cluster life cycle was similar to that of a product or industry life cycle, suggesting that there maybe an inherent link between the cluster and industry life cycles.

A cluster life cycle has a growth, maturity saturation and decline phase, as supported by Pandit et al (2001) and Wolf et al (2005). The later work goes a stage further and devises a graphical representation of this cycle. The terms used: latent, developing etc imply a very process driven system behind a cluster. These terms also to an extent imply rightly or wrongly a linear process, that is a latent phase developing and into established phase. This does not allow the possibility of alternative mechanisms creating clusters. The Swann framework has at its core a more flexible approach to cluster dynamics, focusing on positive and negative feedback effects that govern the operation of a cluster. Positive feedback effects include productivity growth supported by the research of Henderson (1986) as well as innovation from the companies in the cluster; this is also heavily supported by other work such as Breschi (2001) and Wu and Chen (2001).

Negative feedback comes in the form of a congestion of firms in economic space, resulting in labour shortages, as well as increased competition in the input and output markets, which in turn can result in the eventual decline of the cluster, as noted by the work of Swann (1998). It is interesting to see that both of these effects are akin to the centripetal and centrifugal forces discussed by Krugman (1998).

The work by Swann also adds to the fixed effects of feedback relationships. These influence how attractive a cluster is to firms on the outside but are not altered as the cluster develops, which can include climate, infrastructure and cultural capital. Figure 14 depicts the effect of positive growth on a cluster.

Figure 14. Swann Model cited Pandit et al (2001)



The same work also usefully, constructs an analysis of the benefits and costs of being in a cluster, but rather more critically than literature such as Cumbers and MacKinnon (2004). The most important and innovative component of the analysis is the decision to look at costs and benefits, in terms of both the demand side and the supply side. One of the primary positive arguments on the demand side hails from the work of Hotelling (1929). Swann agrees with the notion of Hotelling's market stealing effect, whereby firms in the same geographical location will take market share from rivals[1]. In addition to this, he considers customer proximity as well as reduced customer search cost to be the key benefits on the demand side, even against the costs of congestion and competition in the output market.

On the supply side, the benefits are dominated by good infrastructure and specialised labour. The other positive supply side effect, is the presence of knowledge spillovers, an advantage which has also been noted by authors such as Arrow (1962) as well as Feldman (1993). Moreover, some of the more mainstream economic literature has also observed the presence of spillovers and their positive effect on endogenous growth in work such as Romer (1986), Lucas (1988) and Grossman and Helpman (1994), all pointing to their ability in generating growth. The costs are again thought to be the same on the supply side but it is the input market which is affected by congestion and competition.

[1] In the short term the traditional location pricing model will lead to a Nash equilibrium. However, if further firms enter the area or the firms in the cluster choose to react in an unorthodox manner, i.e. against a cost minimising strategy, then no equilibrium maybe reached. For a full discussion of the model and its effects see McCann (2001).

It has become clear from the work reviewed here that one of the most compounding dynamics in a cluster is the presence of knowledge spillovers. This is not entirely unexpected and even as far back as Marshall 1880, the notion of knowledge creation was known.

Yet, if this is the key dynamic of a cluster than is it possible to measure the contribution of this factor alone? Audretsch et al (1996) conducted an extensive literature review of the topic and although noting the problems of empirical analysis of knowledge they also outline the numerous proxy measures in existence. In addition, relatively recent work by Jaffe, Trajtenberg and Henderson (1993) used patents as a proxy for knowledge and patent citations within literature as a form of spillover measure. The results were positive and they found that more patent citations occurred in the state where the patent originated than from outside of it. Work by Hakanson (2005) touches on localised knowledge, or clusters of individuals rather than firms, where by knowledge can be exchanged and passed on between people. The author particularly focuses on the wording of this knowledge and deliberately refrains from the term spillovers and instead simply refers to it this as 'knowledge externalities'.

Hakanson's work links back to the argument that networks are at play and in particular, when speaking of knowledge exchange as a dynamic of clustering, it is inferring some form of relationship between members of the cluster. Gordon and McCann (2000) when focusing on networks, after detailed analysis come up with what they see as the rational for the existence of relationships between firms in clusters. It is not being inferred in their paper, but one could make a link between their work and Hakanson's, and the presence of knowledge spillovers as a dynamic of clustering. The Gordon and McCann work sought through qualitative and quantitative analysis to establish the relationship between perceived drivers of clustering and spatial concentration.

The results were interesting but most intriguing was the finding that "innovation in product or processes associated with observation of or collaboration with other businesses" were according to the research entirely unrelated to the degree of concentration. Ordinarily the odd result would not be cause to merit a major rethink but due to the large sample, n= 3800 and the proficiency of the authors in this field the finding must be keenly looked at. It maybe from these results too premature to declare knowledge creation is the key dynamic in clustering. What has not been explored up to this point is the nature of the information spillovers. There is one key element to knowledge, and that is the form it takes. Knowledge can be classified as codified and tacit. The key difference being that tacit knowledge (as noted by Cowan et al (2000)) is important but cannot be articulated easily, this is information which cannot be passed on in a simple manner. Hakanson notes that tacit knowledge is both difficult to imitate and to voluntary replicate, but conversely the opposite can be said of codified knowledge.

He also expresses the notion that this form of knowledge flows without hindrance and nearly without cost. Rightly or wrongly he points to its ability in bringing about technology transference and increase the chances of involuntary imitation, this is firms not trying but ending up using the knowledge.

However due to the this characteristic it has left some authors believing it to only generate limited competitive advantage in the short run before being adopted into the industry as a whole. If this is indeed a cluster dynamic work by Maskell and Malmberg (1999) may lead one to conclude that clustering cannot occur between all organisations but instead among a selected few.

The authors conducted a large study of firm interaction and knowledge transference and came to the conclusion that "... where firms share the same values, background and understanding of technical and commercial problems, a certain interchange of tacit knowledge does in fact take place." To this point, all the work on spillovers leads to the conclusion that spatial proximity aids the knowledge diffusion thus leading to these technology spillovers. Although, new evidence from Bathelt et al (2004) has begun to open the door to the possibility that proximity is losing its importance. In a rather complex metaphor, the work describes "global pipelines"; these are conduits linking individuals or firms across economic space constructed from high technology linkages such as broadband as well as other digital networks. The authors do not focus on the precise nature of these linkages as noted by Hakanson (2005) but they do elude to the fact these "global pipelines" maybe a way of conveying tacit knowledge rather than meeting face to face, thus eliminating the argument for proximity among firms. However, the argument is still in its infancy and little other evidence other than anecdotal exists.

This being said, authors have begun to take note, in particular, attention should be drawn to the work of Gertler and Levitte (2005) who acknowledge the existence of cooperative exchanges between organisations focusing on the use of communication technology. They argue that geographical distance is no longer an issue for most corporations who utilise good communication technologies. What's more, little of the research so far, has addressed sector specific issues and this is noticeable from the literature in general. There is an exception the work of Niosi and Zhegu (2005). The work looked at spillovers in both the aerospace as well as the biotechnology industries as to key different cluster groupings.

They stated that the aerospace industry is remarkably different in structure compared to that of most other industries such as biotechnology, automobile, and information technology. The first considerable difference was the fact that aerospace clusters have strong international linkages. This is in terms of input output linkages, with large amounts of components being shipped in from overseas thus limiting the possible knowledge transfers. However, this as the authors noted, is not necessarily a problem. This is because, these forms of international linkages are highly structured in nature by major firms and thus link businesses into global markets, although this means the traditional spillover is more spontaneous and less structured with new ideas emerging over time. Overall they concluded, that the amount of knowledge being transferred in aerospace is considerably larger than that of biotechnology firms.

This insight into multiple sectors now raises some very large issues. Are spillovers of a generic type or are they more or less the same? If the answer is the former then one must question the ability to ever truly understand or model these spillovers. Nevertheless, one thing is for sure, the study has shown that all the industries looked at (please refer to Niosi et al (2005) for the full list), are experiencing some form of cluster thus justifying the argument that spillovers are the key attribute of a cluster.

The debate so far in this section focuses on human externalities rather than other forms of spillover, however there is a considerable amount of literature focusing on other forms.

Technology spillovers have come into play in a great number of recent works such as Watanabe et al (2002), Fosfuri et al (2004), Baldwin and Martin (2004), Bwalya (2006), De Propris et al (2006) and Liu et al (2007) which have all examined the effect of technology spillovers in clusters. The interesting divergence between human capital spillovers and technology is in the types of firms that are capable of taking part in these spillovers.

That is to say, the interaction of clusters is governed by its membership. This is a logical conclusion and thus, fundamental in understanding the notion of a cluster. De Propris et al (2006) for example, looked at the presence of foreign manufacturing corporations in clusters. They came to the conclusion, that traditional government policy aimed at creating clusters which involved bringing in foreign operations to green or brownfield sites would not yield successful technology spillovers. This is because, there needed to be a pre-existing cluster in place to allow the spillovers to occur. The other major finding from the work was that technology spillovers did not just occur from foreign companies to domestic but also the other way round. This is further supported by Owen-Smith et al in Braunerhjelm (2006), who demonstrated that successful technology transfers occurs between firms when "Asymmetries in technological, regulatory and financial muscle drove early collaborative patterns in industry". However, this notion is not supported by all and some believe that technology spillovers have actually occurred between firms of both different sizes and at different stages of development. For instance In the pharmaceutical industry, the early pursuit into the new field of biotechnology was done by large firms relying on small firms in close proximity who had specific pieces of knowledge lacking by the large organisation, noted in Powell and Brantley (1992).

Baptista et al (1998) have added to this debate, commenting that technology spillovers have been written about both in terms of productivity growth Griliches (1992) and Nadiri (1993) as well as in the new economic growth literature Grossman and Helpman (1994). In each case, it is the localised nature of these spillovers that the author notes as being at the heart of the process. Pavitt (1987) links the idea of both human as well as technological spillovers as one and the same and in doing so latches onto the idea of codified and tacit technological knowledge.

He proposes that new technological knowledge of a tacit nature will flow far easier locally than over a greater geographical distance. This was supported even further back in the literature by the work of Nelson and Winter (1982). They emphasised that tacit technological knowledge can only be acquired through everyday practice. The notion of knowledge spillovers also fits well into an establishing base of literature focusing on clustering and entrepreneurship or innovation, (see for example Schoonhoven and Eisenhardt (1992)).

The two concepts sit well with one another, supported by Feldman et al (2005) who go a stage further and actively encourages the notion that entrepreneurs spark cluster formation and regional competitive advantage. Entrepreneurs being catalysts of innovation has long since been known and is ingrained in their very nature but for an updated view on this topic please see Lipparini and Sobero (1994) and O' Regan et al (2006). Both of these works note the importance of entrepreneurs in generating innovation amongst firms. Rocha and Sternberg (2005) undertook a detailed econometric analysis to investigate the topic. What they found, was that entrepreneurship is positively linked to cluster development and growth.

Evidence on this is not without criticism and in fact a greater number of papers look at the traditional "chicken and egg" argument. Martinez and Sánchez (2008) found that far from driving clusters, it was clusters themselves which created entrepreneurs. This is also supported by the work of Hector (2004) who looked at development economics, clusters and entrepreneurship. He again found evidence to suggest a positive relationship between clusters and entrepreneurship and in particular, focuses on innovation and knowledge exchanges. If we come back to the initial definition of a cluster in this chapter, Michael Porter himself acknowledges the ability to innovate "provides a long term sustainable advantage for a firm or a region" Porter (1989) cited Feldman (2005).

The innovation element of entrepreneurship is firmly the key to the link between both concepts. Further work by Romanelli et al (2004) see entrepreneurs acting as agents who sort the resources of a group of firms into functioning clusters. Clearly in this form of analogy, the entrepreneur is seen as the creator of clustering behaviour.

3.6. Conclusions

This chapter has tried to synthesis the past decades of cluster literature in order to give the reader a better perspective on the topic. (However, in drawing this section to a close, one cannot be entirely certain whether this has been achieved from this work).Numerous definitions of a cluster have been found during the research for this chapter. Studies on the dynamics of this phenomenon are even more wide spread with research papers, numbering into the 1000's.

In spite of this, what can be deduced is the ever increasing interest from both academics as well as policy makers in this field. Take for example the UK government who have spent a great deal of money buying in the expertise of academics like Michael Porter in an effort to establish whether clusters are in existence. The trouble with such an all encompassing topic, is that it is hard to see where a cluster ends and concentrations of industry begin. The other area which was deliberately left to one side in this chapter, was the matter of economic development. Studies such as Learmonth et al (2003) and Newlands (2003) have attempted to establish a link between clusters and economic growth, both papers finding some evidence of a relationship. The complexity of finding a link between these two does not add greatly to establishing a precise definition. These forms of studies have added to an unfortunate understanding of what clusters have become, and being interpreted by policy makers, as ***economic tools, rather than a phenomenon***.

That is to say, policy makers believe they can exploit something, which it's claimed, can create enormous growth and deliver to the country/ region where they wish it to happen. One cannot but be alarmed by this notion, when exploring the basis for this cluster literature. Marshall's original notion of agglomeration is as far removed from most government policy to create clusters than is possible, the first conception of agglomeration being that of a natural force which exists in the economy, created as the result of different elements coming together, such as, labour pooling. A great deal of the literature explored here has charted the effects of numerous clusters and many different ways.

The only certainty in most cases was that there are differences within them all. What now needs to be done is to better explore the existence of agglomerations, how are they spatially separated and do they form unique patterns in the economic landscape. This will be the mission for the remainder of this thesis.

The literature examined throughout the course of this and the previous chapter has looked at the many differing definitions on what a "cluster" is. The focus has been on exploring the structure and the benefits of economic "clusters". More importantly it has looked at the traditional literature of agglomeration in trying to understand what it means to have a cluster or concentration of industry. What could be surmised to this point is that agglomerations are mathematical and specific, whereas clusters are intuitive and vague. After considering numerous definitions of what is meant by a "cluster" this thesis will now consider how to draw these two together to identify them.

Chapter 4: Methodology: Identifying and Measuring Clusters

4.1. Introduction

The initial chapters of this work have explored the concepts of spatial economics, with particular attention focused on agglomeration and as some authors have referred to clustering of industry. This chapter will seek to explore the methods currently used to identify clusters. Particular focus will be put on the quantitative techniques and a distinction will be made between techniques exploring cluster analysis and specialisation.

4.2. Identifying and Measuring Clusters

When using the notion of agglomeration what has not been clear in the literature to this point is defining characteristics of the phenomenon. Agglomeration maybe thought of as being closer to "clustering" than simply a physical concentration of industry. Therefore it is necessary to construct specialisations of industry rather than trying to identify just concentrations. The dispute over the precise nature of clusters and their perceived benefits will continue on, but it has not stopped researchers from formulating methods to try and identify them. The approaches are varied and a good record of these is the "Cluster Meta Study" conducted at Harvard University. The study identifies 833 clusters around the world from Australia to Switzerland and South Africa to Venezuela. The study was compiled by taking the findings from 25 different cluster projects each of which uses different methodological approaches. The obvious problem with this is the lack of consistency and comparability in the findings.

One of the earliest studies that looked at the identification of industrial clusters was the 1979 work of Czamanski and Ablas (1979). The paper talks of clusters and complexes referring to the work of Christaller (1966) and Isard (1975), with a focus on the linked flows of trade between firms existing in close proximity to each other.

The authors utilise previous work comprising of 60 types of industrial groupings, which by their own admittance showed little difference existed in the spatial sectoral composition of the clusters. The first study analysed was that of Streit (1969) who looked at the geographical association between groups of industries.

Certain characteristics within these projects are the same, such as the influence of the Porterian school of thought. There are however, a number of approaches that have appeared consistently over the last 20 years, and these can be broadly summarised into three groupings, quantitative, qualitative and mix methods.

4.3. Quantitative

Quantitative techniques, for example Brenner (2001), adopt a form of statistical measure to ascertain the distribution of industry. More than often this approach also employs some form of mathematical derivation of the inter-linkages (forward and backward) between firms in the same industry such as Berwert (2000). It is noted by Baldwin et al (2007), that this form of analysis falls into two brackets, employees' aggregate data covering metropolitan areas and the micro data approach.

The first supports the notion of localisation economies resulting from spatial concentration. Whilst the second has allowed researchers to investigate individual sectoral concentrations, exemplified by the work of Ellison and Glaeser (1997).

4.4. Qualitative

The second method of identification uses a qualitative approach, focusing on industries that appear to exist within clusters. These studies vary greatly in depth and also in rigour, often based around a case study approach, such as Holmes et al (2005). These studies offer insight into very specific interactions between firms but whether these can be converted into a typology of classification mechanism for other clusters is doubtful.

4.5. Mixed Methods

The final approach is the mixed methodology of combining both of the above methods sometimes referred to as a data triangulation method. The most cited of these studies is the work of Porter (1998) who identified clusters within the United States through a combination of statistical measures such as the location quotient (LQ) and questionnaires designed to understand the relationship between firms. The work of Held (1996) supports the notion that policy makers prefer to adopt this mixed method approach.

One of the most notable was the DTI cluster analysis of the UK. Its rationale for using such a framework came after long consultation, (Brown, 2000) with the goal of trying to capture every form of cluster without specifying too many procurers. This process of identifying clusters in particular, with the use of empirical data has been termed 'cluster mapping', Ketels (2003). The origin of this, like a great many things in this field comes from the work of Porter. Porter's initial method of analysis involved first calculating concentrations of industry by using the traditional location quotient method.

Porter then calculated the correlation of employment by industries across locations; these were then grouped in clusters and sub-clusters. Due to the popularity and the continuing research interest coming out of the Harvard business school, the method was also adopted by sister cluster mapping projects in Canada and Sweden. Due to the many different techniques that are littered throughout the cluster literature, a summary of some of the main techniques are explored in the next section of this chapter.

Roelandt and den Hertog (1999) examined different quantitative techniques used in cluster studies: Table 6 summarises these findings. The authors note the importance of input output analysis in recent cluster work but they also acknowledge the continuing pattern of multi procedural studies with large numbers of papers using both qualitative and quantitative work.

Table 6. Modified from Roelandt and den Hertog (1999)

Methodology	Technique	Primary data	Focus
Quantitative	Input-output analysis	Input-output matrices, innovation surveys	Trade linkages between industries in the value chain in the economy
Quantitative	Graph analysis	Innovation surveys, input-output tables	Cliques and other network linkages between firm and industry groups
Quantitative	Correspondence analysis	Innovation surveys	Groups of firms or industries with similar innovation styles
Quantitative	Case studies conducted in the framework of Porter's diamond model	Qualitative data combined with trade statistics and national accounts	Factors affecting the competitiveness of industries and nations

The techniques identified by Roelandt et al are not that different from one another. The only distinction between the methods appears to be the focus, with different groups of stakeholders being targeted in the findings. One of the traditional tools within cluster analysis is the Location Quotient (LQ) first used by Chinitz (1961). The continued used of this technique for over 40 years warrants further exploration of the tool.

4.6. The Location Quotient

Quantitative techniques that look at the specialisation of industry could be dated back as early as the 1920's with the work of Haig. This work sought to understand the industrial make up of New York and resulted in the construction of the economic base model, which split the economy of a region into two sectors the basic and the non-basic. Basic sectors are those exporting from the region, usually resource driven industries such as mining and manufacturing industries, and non-basic sectors are the service industries, which support the basic sectors. To identify the sectors, a comparative analysis of employment figures for individual industries is adopted, comparing the regional level to the national level. The method is known as the location quotient and it is constructed as in equation (15). Employment is not the only data that can be used in location quotient calculations and indeed other studies such as Guimaraes et al (2008) used both establishment level and employment data. Theoretically the quotient maybe calculated with either values as was done by De Propris (2005) to establish the relative dominance of a particular characteristic. The focus in most cluster research is on labour pooling and thus employment level data is preferred.

$$LQ_i = \frac{\frac{E_{ir}}{E_r}}{\frac{E_{in}}{E_n}} \quad (15) \qquad = \frac{E_{ir}}{E_{in}} \times \frac{E_r}{E_n} \quad (16)$$

The location quotient for a particular industry (i) within a given region (r) is equal to the employment within that industry divided by the aggregate employment of the region, all over the national level of employment in the industry (E_{in}), divided by the aggregate employment of the country (E_n).

If the location quotient is greater than one then the region has a greater share in that industry than the national level, as such it could be inferred that the region is a specialist within this area. The use of the LQ has been consistent within the regional economic literature since the 1940's (Gibson et al (1991)). One of the major factors, which has also maintained its popularity as, noted by Isserman (1977), is the little data required as opposed to survey methods of research. The work of Gibson et al (1991) describes the quotient as fielding a coefficient of how represented an industry is within a region. With this in mind, it can be easily seen how this was adopted as the measure of choice in spatial studies investigating industrial clustering or agglomeration.

Within cluster studies this measure has been used across the board for many years see for example Sforzi (1990), Brusco and Paba (1997), Porter (2000) the DTI cluster report (2001) and De Propris (2005).

The simple nature of the measure does however leave it open to criticism. Shaffer (1999) notes two significant problems, which have appeared with derivation of the technique. The first issue is that due to the formulation of the calculation, consumption patterns are thought to be the same over time at the regional level as well as the national, although this is not so serious as consumption is not the primary driver of industrial spatial proximity. The second issue is that labour productivity is said to be constant across all regions. Authors such as Baldwin et al (2007) avoid this problem by looking at wage levels instead of employment figures, yet this has its own problems and is attacked by Shaffer (1999), as it does not take into account the cost of living differentials across regions.

The location quotient method has been amended by some authors to try and improve the calculation by comparing the local industry level to a sample of similarly sized regions. The technique known as the minimum requirements technique was first developed by Ullman and Dacey (1960). It assumes that the "minimum shares region" has just enough employment to satisfy local demand for that industry's goods and services. It follows that all other regions will have some Basic sector employment because their "share" in that industry is greater than that in the "minimum shares region". Klosterman (1990) notes the benefit is that by looking at similar sized regions rather than the nation as a whole gives a fairer comparative. Pratt (1968) counters this perceived benefit by noting that the technique is weaker than the traditional location quotient.

He makes reference to the fact that averages are more meaningful than minimums, the author also shows empirical evidence that the minimum requirements approach is more sensitive to data aggregation than the location quotient. Authors such as Hildebrand and Mace (1950) and Karasha (1968) found empirical evidence to support this notion also, in particular Karasha found that input output coefficients deriving economic linkages are adversely effected when using highly aggregated data.

4.7. Input Output Analysis

Another common method of cluster analysis is the input output (I/O) table approach. This is based upon examining the linkages in the traditional regional or national model as described by Leontief (1956). The conception of the model was as a basis to allow the quantification of exchanges between different sectors in the economy.

I/O tables allow the identification of how industries are related through forward and backward transaction linkages, as noted by Nilsson (2001). Once these linkages have been found the establishment of clusters is determined by the minimum share or quantity of trade to classify an industry as being in a cluster, a method which is explained in great detail in DeBresson and Hu (1999). Essentially, this is done by using a principal component factor analysis like Hofe et al (2007). The (I/O) tables were used for this purpose over the 1970's and 80's by academics such as Czmanski (1976) and O hUallachain (1984). In order for the tables to be relevant for regional cluster analysis, it has been suggested that sub regional tables be used, i.e. tables derived from national frameworks but for specific regions.

An example of these form of tables and details of its construction can be found in Roberts and Hill (1996). The major criticism of the I/O approach is in the fact that national tables do not allow regional comparisons to be made easily, yet sub regional tables also have their own problems. For Instance, Feser and Bergman (2000) commented on the exclusion of non local buying/ selling patterns from sub regional tables creating industry bias. The other major problem of these tables as raised by Hofe et al (2007) is the inconsistency in methodological approaches used by different organisations.

Another issue raised is the lack of spatial awareness from the findings, put simply there is no spatial dimension to the empirical data. For a fuller discussion on the problems of sub regional table construction, see Madsen and Butler (2004).

4.8. De Propris Methodology

The techniques consider here are the most common methods used by both policy makers and academics alike. But these methods when used improperly or without employing some form of typological form, any of the techniques mean nothing.

De Propris (2005) developed a multi- procedural approach to cluster analysis by combining a number of existing measures into one framework. It combines measures of specialisation and firm size in order to establish the relative industrial composition of a region. By looking at these particular traits De Propris classifies clusters. The methodology involves 4 types of analysis:

- Manufacturing Intensity Calculations
- Firm Size Analysis
- Location Quotient
- Sector Size Measures

4.9. The De Propris Method Explored

Existing methods of characterising the nature of the manufacturing sectors typically rely on location quotients derived from regional and national data. Location quotients use a methodology that summarises relative employment in each industry, by relating that industry's local employment share to its national employment share, (Klostermann , 1990).

By calculating and comparing these two figures, it is possible to contrast the regional level against the national level, hence giving an understanding of relative sector size rather than using absolute but scale-dependent employment statistics. The location quotient then allows the identification of areas of relative manufacturing intensity. Location quotients were first used by Robert Murray Haig in 1926, derived from his work on economic base analysis. Recent work from authors such as De Propris (2005) and Markusan (1996) demonstrate their effectiveness in the study of economic agglomeration. The greatest advantage of their use is the ability to compare like with like.

The location quotient, is given by formula (17):

$$LQ_{ir} = (E_{ir} / E_r)/(E_{in} / E_n) \quad (17)$$

Equation (17) gives the location quotient for a particular industry (i) within a given region (r). This is equal to the employment within that industry (E_{ir}) divided by the aggregate employment of the region (E_r) divided by the national level of employment in the industry (E_{in}). This is then divided by the aggregate employment of the country (E_n). Hence the employment location quotient for a particular sector and region divides the sector share of *regional* employment by that sectors share of *national* employment.

For the purpose of this research a derivation of this calculation will be used

$$LQ_{ir} = (E_{ir} / E_r) > (E_{in} / E_n) \equiv \text{In}_{ir} \quad (18)$$

This has been utilised by De Propris (2005); using the two separate components of the equation as a measure of relative intensity. That is to say, the share of a particular regional attribute such as manufacturing as a ratio of total economic activity is contrasted against the UK ratio. If the value is equal to or greater than the UK share, then the region is said to be manufacturing intensive. The second measure utilised in this research concerns firm size.

This is not new in agglomeration analysis, authors such as Blundell et al. (1995) and Ellison and Gleaser (1997) note the importance of industrial composition in terms of firm size as an important dimension of an analysis. The relative sizes of firms can be important in determining the economic structure of a region.

The importance of firm size is often considered in terms of Gibrat's law of "proportional growth" Licht and Nerlinger, (1998) and Storey and Tether, (1998). The law states that "the probability of a given proportionate change in size during a specified period is the same for all firms in a given industry, regardless of their size at the beginning of the period" Gibrat cited Calvo (2002). However, Gibrat's law when tested empirically has yielded mixed results. Calvo (2002), when examining Spanish regions, found significant evidence that small and medium size firms showed greater growth than their larger counterparts in more economically developed areas. This is in contrast to the work of Evans (1987), who found that mean growth rates in a 20,000 firm analysis showed a proportional relationship between firm size and growth. Further evidence over firm size and growth is provided by Wagner (1992). The work used a highly detailed panel data set and found among other results that within the German manufacturing industry firm size is not related to the proportion of long lasting jobs.

The next stage in this method is to focus on those areas identified as manufacturing intensive and look at their composition in terms of firm size, using familiar categorisations of small, medium and large. The procedure for estimating firm size quotients is similar to the earlier sector calculations, now using different size brackets rather than sectors. The number of employees currently employed in a firm defines the given firm size.

Three size groups were pre-defined[2]: small firms are those with 1-49 employees, medium between 50-199, and large firms have 200+ employees. The first issue was to determine whether or not small firms have high intensity in a TTWA.

This is done by simply dividing the number of employees in small firms ($Xi\mu r$) by the total number in manufacturing within the TTWA (Xi), and comparing this figure to that for the whole UK. This is then calculated in a similar manner for the other two firm-size groupings. It must be highlighted that these figures are only calculated for manufacturing based businesses and other sectors are not included. This may be derived as:

$$\mu = \begin{bmatrix} 1 - 46\ (small) \\ 50 - 199\ (Medium) \\ 200 + (Large) \end{bmatrix}$$

$$\left(\frac{Xi\mu r}{Xi}\right) \geq \left(\frac{Xi\mu N}{XN}\right) = Manufacutring\ Intentisve$$ (This is higher than the UK level).

The next stage of the De Propris method is to utilise the traditional LQ calculation. This is used to identify sectors or industries which have clusters. The traditional formulation is constructed by De Propris using employment information.

[2] These values were used based upon current EU classification statistics.

The final measure in the De Propris methodology attempts to capture what size firms are involved in the specialisation of the industry. This is a crucial aspect of agglomeration to look at, as seen in chapter 3, firm size appears to be an important determinate in both defining and explaining the functioning of agglomeration. It was used in the De Propris methodology to help incorporate the definitions suggested by the work of Sforzi (1990). These classified local production systems or agglomerations according to their ranking in the criteria utilised by De Propris. These six definitions could be seen as stages in the development of agglomerations. These were Pre-districts, specialised small firms, medium and large firms, specialisation without agglomerations, large firms, and finally none manufacturing agglomerations.

The fundamental technique employed in most of the De Propris methodologies is the LQ. Like most statistical techniques estimation of data is employed, as such variance of the point estimates yielded by the LQ must be considered.

4.10. LQ Significance

This work has reviewed the numerous methods used to identify clusters, many of which employ the LQ technique in some shape or form. To this point, literature examined has focused on setting arbitrary cut off points thus determining the significance of the calculated quotient. For example the DTI use the value of 1.25, other work opts for 3 Malmberg et al (2002). Which value is therefore considered to be correct? The key to understanding which value to use as a cut off point is to calculate the relative significance of the location quotient. If an LQ is greater than 1, then the share of the industry in the TTWA is greater than the relative share at the national level.

Therefore the exercise here is to establish whether or not a particular LQ is significantly greater than 1, thus negating the use of arbitrary cut off points. The calculation of LQ's from government data is not a precise science and it is often questioned whether the results are accurate, Donoghue and Gleave (2004). In the UK one of the most used sources of data is the National Statistics Office, which conducts the annual business enquiry survey. The methods they use for the collection of raw data are based upon a mixture of different techniques from survey to statistical analysis. To this end, the data provided is simply an estimate of the actual figures and as such has a degree of variance associated with it. The first step in determining the accuracy of the quotients should be to understand the nature of this variance, therefore to do this the distribution of the statistic needs to be established.

Little social science research and even less economic research has been carried out on this problem, with the exceptions of Silcocks (1994), Thrall et al (1995) as well as Beyene and Moineddin (2005).

Most notably are Donoghue and Gleave (2004), who suggest a standardised location quotient. This allows significance to be determined across different size samples, however this does have some stringent limitations, for full discussion see Donoghue and Gleave (2004).

The traditional problem noted by Beyene and Moineddin (2005) with the standard LQ method is that of obtaining single point estimates for the particular characteristic being examined. This implies no measurement of statistical error, or the degree of accuracy of a particular value, based upon the overall data set being employed.

The simplest technique that could be applied is the calculation of a T test comparing the LQ for a particular industry in a region, with that of the other LQ's calculated from other regions.

Thrall et al (1995) adopted a similar approach when looking at the calculation of LQ's for the number of mortgages given by different financial institutions. They used a T test to determine how similar an individual LQ for one institution was compared to an aggregated LQ determined by looking at all the institutions.

This however, has the distinct drawback of taking the calculated point estimates as being absolute rather than estimates. Beyene and Moineddin (2005) choose to utilise a more sophisticated approach, based upon the linear approximation of the variance, allowing the establishment of confidence intervals. This calculation is of great value as it is constructed by considering the uncertainty within the estimation procedure involved within the initial calculation of the LQ's. The LQ is a ratio divided by a ratio, the denominator in each case is determined by the spatial domain in which the research takes place. Therefore, areas with high working populations will help improve the accuracy of the statistic; however the relative size of the industry being investigated also plays an important role in determining the specialisation of a sector. By approximating the relationship between these two factors, it allows us to improve the accuracy of the result.

4.11. The Method

Taking the initial LQ calculations shown at the start of this chapter, let us employ similar notation and derive the statistic as follows:

$$LQi = \frac{\frac{Eir}{Er}}{\frac{Ein}{En}} \quad (19)$$

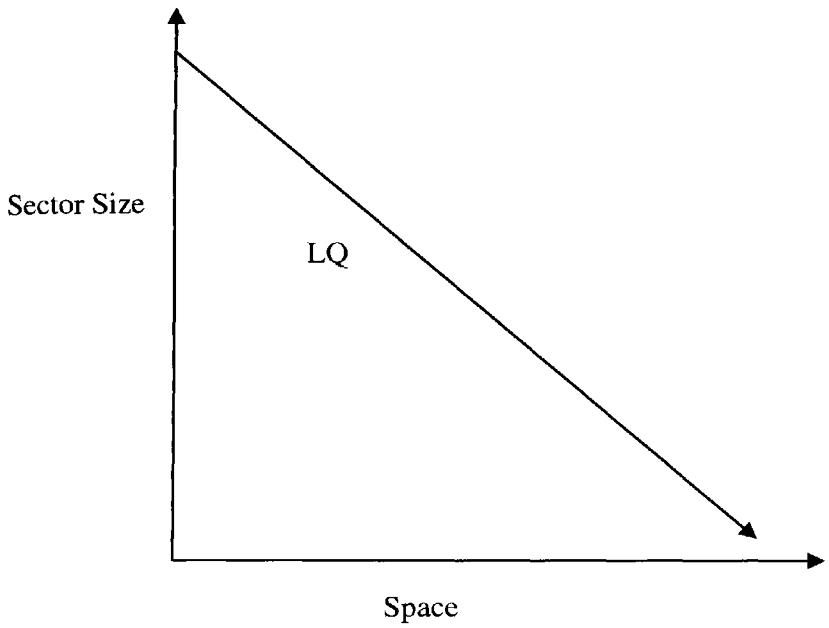
$$\text{LQi} = \frac{Eir}{Ein} \times \frac{Er}{En} \quad (20)$$

If we consider (20) from the location quotient calculation,

$$\text{Let } \alpha = \frac{Eir}{Er} \beta = \frac{Ein}{En} (21)$$

To establish the confidence limits, inference must be made between the two parameters in (21). The inference that occurs is generated because of the two dimensions that make up all LQ (see figure 15)

Figure 15. Two Dimensions of LQ



The relative size of a sector and the size of the space in which it operates, both play a role in determining the relative variance associated with the LQ. For example, if a sector is relatively large and the space is small, the LQ will appear large and the relative variance will appear small. Just as, if the LQ is relatively small and the Space is large then the LQ will be small and the associated variance will be much higher. To establish the inference in the parameters the notation will be used as follows:

Let the parameter $\gamma = \binom{\alpha}{\beta}$ this is a random vector with a mean $\zeta = \binom{\psi_i}{\psi}$. The means are the true incidence rates of an industrial presence from a national level ψ, and a regional level ψi. The true incidence rate is the ratio α, or the number of people employed in an industry compared to the total number of people employed in manufacturing in a region. From this it is possible to use matrix notation to describe the variance, covariance matrix:

$$\begin{bmatrix} V11 & V12 \\ V21 & V22 \end{bmatrix}$$

The notation introduced allows us to use a common statistical operation: the Taylor series expansion. The Taylor series is the representation of any given function by an infinite sum of terms. These are calculated from the values of its derivatives at a single point Thomas et al (1996). For the purposes of this research its result is used by following the delta method Oehlert (1992).

"The delta method is a general approach for computing confidence intervals for functions of maximum likelihood estimates" XU and Long (2005). The delta method is used to evaluate complex functions, that is to say, one that is too complex for analytically computing the variance. The method creates a linear approximation of that function, and then computes the variance of the simpler linear function; this can then be used to establish large sample inference. The Delta approach allows the expansion of g (γ) at the point when $\gamma=\zeta$, this allows the calculation of an approximate variance of g (γ). This employs the well known statistical method Taylor's theorem. This is currently the only methodological approach possible without using more complex analytical techniques (e.g. multinomial methods).

Taylor's theorem allows any smooth function to be approximated as a polynomial. Taylor series approximation allows the calculation of the value of a function at one point, in terms of the functions value and its derivatives at another point.

Taylor theorem states that if a function f and its first n+ 1 derivative are continuous on an interval containing α and x then the value of x is given by:

$$f(x) = f(\alpha) + f'(\alpha)(x-\alpha) + \frac{f''(\alpha)(x-\alpha)^2}{2!} + \frac{f'''(\alpha)(x-\alpha)^3}{3!} + \cdots + \frac{f^n(\alpha)(x-\alpha)^n}{n!} + R_n$$

$$Where\ R_n = \int_\alpha^x \frac{(x-t)^n}{n!} f^{n+1}(t)\,dt$$

t = Taylor's series

The expression of a Taylor series for a variable x is given by:

$$f(x_{t+i}) = f(x_i) + f'(x_i)(\Delta x) + \frac{f''(x_i)(\Delta x)^2}{2!} + \frac{f'''(x_i)(\Delta x)^3}{3!} + \cdots + \frac{f^n(x_i)(\Delta x)^n}{n!} + R_n$$

$$Where\ R_n = \frac{f^n(\xi)\Delta x^{n+1}}{(n+1)!}$$

In this example the approximation says that ξ lies between x_i *and* x_{i+1}

The first order Taylor series expansion of the function suggested in this research is given by:

$$g(\gamma) \cong g(\zeta) + \frac{\partial g}{\partial \alpha}\bigg|\zeta(\alpha - \psi_i) + \frac{\partial g}{\partial \beta}\bigg|_\zeta (\beta - \psi)$$

Simplified to:

$$g(\gamma) \cong \frac{\psi_i}{\psi} + \frac{1}{\psi}(\alpha - \psi_i) - \frac{\psi_i}{\psi^2}(\beta - \psi)$$

The variance of g (γ) is given by

$$V(g(\gamma)) = \frac{1}{\psi^2}V(\alpha) + \frac{{\psi_i}^2}{\psi^4}V(\beta) - \frac{2\psi_i}{\psi^3}Cov(\alpha, \beta)$$

With the use of TTWA's, it is possible to make the following assumption, that the area under study is partitioned into k non-overlapping regions. (For the purposes of this analysis the following new notation will be used (n_i) before (Er) is the total manufacturing population in a particular TTWA and (x_i) before (Eir) is the number of people employed within sector i in the TTWA). We assume that the distribution of x_i is binominal with the parameters of total population n_i, and the true incidence rate ψ_i .

Now

$$E(\alpha) = \psi_i$$

$$V(\alpha) = \frac{\psi_i(1-\psi_i)}{n_i}$$

$$\chi = \sum_{i=1}^{k} x_i$$

$$n = \sum_{i=1}^{k} n_i$$

$$\beta = \frac{x}{n}$$

Given this the variance and expectation of β are derived respectively:

$$E(\beta) = \frac{\sum_{i=1}^{k} n_i \psi_i}{n}$$

$$V(\beta) = \frac{1}{n^2}\sum_{i=1}^{k} n_i\, \psi_i(1 - \psi_i)$$

The n is a large value within this research close to 3,000,000. We can make the assumption that the x/n is fixed not random, or another way of putting it is that all ψ_i are approximately equal. This implies that the incidence rate is the same in all areas for an industry, ignoring any spatial variation. This is a restrictive assumption and means that a greater component of the measure is said to be non random. This approximation is used as a substitute for individual incidence rates as with large sample sizes the relative change in the true incidence rate is negligible (Moineddin et al, (2003). The benefit of the approximation is the decrease in time it takes to feasibly run the calculations. With industries numbering into the thousands individual incidence rates are impractical within this form of work. Having noted the lack of substantial differences in values approximation appears to be a suitable alternative in this research.

Therefore it is possible to approximate the variance for β as,

$$V(\beta) \cong \frac{\psi(1 - \psi)}{n}$$

$$\psi = E(\beta)$$

$$Cov(\alpha, \beta) = Cov\left(\frac{x_i}{n_i}, \frac{x_{1+\cdots+}x_{i+}x_{i+1+\cdots+}x_k}{n}\right)$$

$$= \frac{1}{nn_i} Cov(x_{i,} x_1 + \cdots + x_i + \cdots + x_k)$$

$$= \frac{1}{nn_i} \sum_{j=1}^{k} Cov\,(x_{i,} x_j)$$

$$= \frac{1}{nn_i} Cov(x_{i,} x_i)\; assuming\; Cov(x_{i,} x_i) = 0\; for\; all\; i \neq j$$

$$= \frac{1}{nn_i} V(x_i)$$

$$= \frac{\psi_i(1 - \psi_i)}{n}$$

Assumptions can be made regarding the covariance if autocorrelation is considered negligible. With this data, the lack of continuity, that is to say, not all TTWA's have a presence of every industry, means that autocorrelation becomes less of an issue. The covariance with this assumption will take the form of a spatial power expression.

Having already defined the Variance of (g (γ)), it is now possible to incorporate this along with the Covariance of (α, β) into the confidence interval formula.

$$V\left(\frac{\alpha}{\beta}\right) = \frac{V(\alpha)}{\psi^2} + \frac{\psi_{iV(\beta)}^2}{\psi^4} - \frac{2\psi_{iCov(\alpha,\beta)}}{\psi^3}$$

$$= \frac{\psi_i(1 - \psi_i)}{n_i \psi^2} + \frac{\psi_{iV\,(\beta)}^2}{\psi^4} - \frac{2\psi_i^2(1 - \psi_i)}{n\psi^3}$$

$$= \frac{\psi_i(1 - \psi_i)}{n_i \psi^2} + \frac{\psi_{i\sum_{j=1}^{k} n_{j\psi_j(1-\psi_j)}}^2}{n^2 \psi^4} - \frac{2\psi_i^2(1 - \psi_i)}{n\psi^3}$$

The variance of (β) is approximated as explained earlier to:

$$V(\beta) \cong \frac{\psi(1-\psi)}{n}$$

The LQ variance simplifies to:

$$= \frac{\psi_i(1-\psi_i)}{n_i\psi^2} + \frac{\psi_i^2(1-\psi)}{n\psi^3} - \frac{2\psi_i^2(1-\psi_i)}{n\psi^3}$$

100(1-α) % asymptotic Confidence interval for a LQ of industry i is given by:

$$\frac{\alpha}{\beta} \pm Z_{\frac{\alpha}{2}}\sqrt{\frac{\alpha(1-\alpha)}{n_i\beta^2} + \frac{\alpha_i^2(1-\beta)}{n\beta^3} - \frac{2\alpha_i^2(1-\alpha)}{n\beta^3}}$$

Due to the large number of industries and the resulting observations for each TTWA, it can be assumed that the statistic has a Gaussian distribution, with the current assumptions holding and using a 95% confidence interval,

$\alpha = 0.05$ $\qquad$ $z\alpha/2 = 1.96$

4.12. Specialisation vs. Concentration

To this point this work has considered various LQ techniques in order to assess the concentration of a particular or group of industries.. It now becomes important to asses the other measures that have been utilised within the existing regional economic literature. To this end a thorough literature search has been carried out that has attempted to bring together the multiple statistical frameworks developed over the course of the last 50 years. When trying to quantify the extent to which agglomeration is present within a region two dominant concepts appear in the literature: regional specialisation and spatial concentration (Traistaru, 2002). Some literature has used these terms interchangeably but it is important to note the significant difference that exists between them.

Regional specialisation is defined as the distribution of shares of an industry in total employment in a specific region compared to a benchmark distribution. For a specialization to exist in a region a specific sector has to have a high share of the total employment for that region Traistaru (2002). On the other hand concentration is the distribution of shares of regions in a specific industry compared to a bench mark distribution.

A concentration is said to exist when a large part of the total employment for an industry is only found in a small number of regions (Traistaru, 2002). Essentially what is being demonstrated is looking at the issue of agglomeration from an industrial or regional level. Bickenbach and Bode (2006) published one of the most extensive papers on concentration and specialisation measures within regional economics.

The authors make the link between inequality measures and those particularly employed within specialization analysis. Some examples of this are the well known: the Theil index, the Gini coefficient as well as the Krugman index. The work makes a clear distinction between the techniques which avoid inequality based measures and in doing so draws a distinction between the 'dartboard' approaches such as Ellison and Gleaser (1997) as well as distance measures such as the work of Marcon (2003) who constructed the so called K function. The work is useful in suggesting a new way of combining the analysis of both concentration and specialization into one. The problem with this work is its reliance on the inequality literature, it seeks to correspondent distributions back to a Lorenz style curve, this is the enforcement of a specific distribution. The important acknowledgment of the work is the simplicity of derivation that can take place with the statistics employed. It is noted that the key index (Theil, Gini, and Krugman's) can be derived to show industrial concentration or specialisation, depending on the scale of the data used.

This work has already focused predominantly on the search for industrial specialization and in doing so attempting to discover concentrations of industry. To this end the focus of this chapters work will be on critiquing and analysing measures of concentration.

4.13. Measuring Concentration

The Herfindahl index, or sometimes called the Herfindahl-Hirschman Index is a concentration measure used a great deal within manufacturing studies such as Kwoke (1977) and Brown et al (1988).

The origin of the measure is unclear but it is thought that the index came about as the result of Hefindahl's PhD thesis entitled the concentration in the U.S. steel industry. The measure can be expressed as follows:

$$H = \sum_{i=1}^{n} s_i^2$$

The index measures the size of firms relative to the industry and thus has been utilised primarily as a tool for identifying uncompetitive business practices. It can be defined as the sum of squares of the market share based upon that of the individual firm. s_i is the market share of the firm (i) n is the summation of all firms within the respective industry. This form of index measures is an absolute with the assumption that no other firms other than those captured by n are thought to exist. Work such as Clemente and Stungis (1971) as well as Henderson (1997) and Duranton and Puga (2000) modified the use of the measure. It is noted by Dewhurst and McCann (2002) that one of the measure changes within recent studies involving the statistic has been to develop the index from a regional perspective. An interesting alternative to this style of index is a counter factual approach developed by Johnsson and Kjellgren (2000).

It involves calculating the numbers of industries not present in the region. This maybe derived by:

$$\sum_{i=1}^{n} \delta_i$$

In this case $\delta_i = 0$ if $s_i\, r > 0, = 1$

A number of alternative indexes have appeared in the literature over the last decade. Krugman's concentration Index unlike the true Herfindahl index acknowledged the difficulty of establishing absolute values for concentrations of industry. To this end he devised a relative measure of regional specialisation. The measure can be defined as follows:

$$K_i = \sum_{r=1}^{R} |\lambda_{ir} - \lambda_r| := \sum_{r=1}^{R} \left|\frac{L_{ir}}{L_{i.}} - \frac{L_{.r}}{L_{..}}\right|$$

The Krugman index is calculated as the unweighted sum of squares of the absolute regional specific differences in employment shares for a given industry i, given by λ_{ir} compared to the aggregate level of employment within the region λ_r. It maybe derived that $\lambda_{ir} = L_{ir}/\sum_r L_{ir} = L_{ir}/L_{i.}$ and $\lambda_r = L_{.r}/\sum_i \sum_r L_{ir} = L_{.r}/L_{..}$. If K_i=0.5 this means that at least a quarter of the industries workforce must be in the area under study to identify a concentration.

With more and more indices beginning to surface the authors Duranton and Overman (2002) began to explore the nature of concentration index. They formulated five major requirements that all measures should verify:

- Comparability across industries
- Controlling for overall agglomeration (defined in a Porterian sense) of manufacturing
- Purging spatial concentration from industrial concentration
- Unbiasedness with respect to the degree of spatial aggregation
- Assessing for statistical significance

4.14. The Ellison and Glaeser Statistic

These criteria are interesting and offering some form typographical mechanism for the analysis of multiple indexes. The most widely used index today is the Ellison Glaeser (1997) (EG) method. The statistic is based upon the comparison of the distribution of plants across economic space against the random distribution of economic activity. It is noted by Bertinelli and Decrop that the random distribution is the expected distribution without the presence of agglomeration forces. The assumption by Ellison and Glaeser are similar to those in other studies of spatial economic clustering. They argue along the same lines as Krugman (1991), in that firms occupy the same area of economic space to benefit from local deposits of natural resources or to internalise costs similar to the Coasien thinking of transaction costs. The first part of the (EG) statistic is a definition of raw geographical concentration:

$$G_i = \sum_c (s_{ic} - x_c)^2$$

The share s of industry i's employment in region c and x is the share of total manufacturing employment in the region. The concentration of a particular industry in this example i is measured using the traditional Herfindahl formula. The index is high for an industry with a small number of firms and with an irregular size distribution. The index is used in an interesting manner, the author's inverse the measure; the result is the number of firms in existence if they were homogeneous in nature. It is intuitive to suggest that the smaller the number of firms the higher the degree of concentration of an industry.

If we assume homogeneity among the geographical units where a firm can choose to locate and in the absence of agglomeratory forces, the geographical concentration of a particular industry is proportional to the Herfindahl index level.

Maintaining the same notation, the EG analysis formulates this as follows:

$$E_i(G_i) = \left(1 - \sum_i x_i^2\right)[H_i + \gamma(1 - H_i)]$$

In the above expression H_i is the Herfindahl of industry i and G_i is the raw geographical concentration of an industry i. Ellison and Glaeser note that if there is no agglomeration then G_i is proportional to H_i. In the presence of agglomeration excess concentration is captured by γ.

This allowed the construction of an estimator of excess concentration $\hat{\gamma}_i$.

$$\hat{\gamma}_i \equiv \frac{G_i - \left(1 - \sum_i x_i^2\right) H_i}{\left(1 - \sum_i x_i^2\right)(1 - H_i)}$$

$$\equiv \frac{\sum_c (s_{ic} - x_c)^2 - \left(1 - \sum_i x_i^2\right) * \sum_{i=1}^{n} s_i^2}{\left(1 - \sum_i x_i^2\right) * \left(1 - \sum_{i=1}^{n} s_i^2\right)}$$

Ellison and Glaeser postulated that industries with γ<0.02 have a relatively low concentration while industries over 0.05 were thought to exhibit high degrees of concentration.

It is also possible under this formulation to have negative values for γ implying there was an even less degree of concentration than would be yielded from a simply random distribution. The index has become popular in industrial concentration analysis.

In the theoretical foundations of the work, they make no claim to understanding the complex intertwining nature of agglomeration and instead base the ascertains of their measure upon the firm location model of Carlton (1983).

This exploration of firm location utilised a random utility maximization framework a kin to McFadden's (1974) work. By utilising this form of analytical rationality inherent randomness is incorporated into the formulation. In previous discrete methodologies such as the location quotient there is a tendency to negate and ignore randomness. One important note that must be attached to the formulation of the EG index that is often over looked in studies is the proxy method the authors used to establish their Herfindahl index. To formulate a true Herfindahl index requires data on every firm within a given jurisdiction to be available. In reality and in particular in the US and the UK this form of data is patchy at best. The most readily available data is information on the number of employees in particular size bands as well as the number of firms within each industry. In place of actual count data these two pieces of information are part of a jigsaw of employment which needs to be fitted together to attain an estimate of the figures. Ellison and Glaeser estimate the Herfindahl based upon a calculation known as the Schmalensee proxy (1977).

This involves estimating employment shares from plant count and employment data for the ten establishment size categories reported in the U.S. Census of Manufacture. To do this a number of assumptions must be made, a uniform distribution of plant sizes over each size range. Additionally the distribution is centred on the mean, bounded by the closest endpoint of the size range. Ellison and Gleaser constructed a simulated data set of 5,000 industries to ascertain the accuracy of their estimated value for H.

The results as noted by the authors show an underestimate of γ by about 0.05. The solution is to multiple the original γ, by a value of 1.05 thus potentially eliminating the bias. This was however decided against by the researchers as they had limited confidence in the simulation. However small the risk of bias, this form of estimating the Herfindahl could be seen as a pitfall in the calculation of the statistic like any procedure relying on estimation rather than absolute values.

The EG index was also augmented by the authors to allow for what they termed the "co agglomeration" of industries this is agglomeration amongst sub-sectors locating separately or together. This is essentially questioning whether firms that agglomerate at the four-digit sector level belong to a common two-digit industry level agglomeration. To do this they formulated a new model that accounted separately for the correlation of firms in the same sub sector and derive a new index, which after normalization can be used to analyse spillovers. The model can be formulated as follows:

$$\gamma^c \equiv \frac{\left[\sum_i (s_i - x_i)^2 / \left(1 - \sum_i x_i^2\right)\right] - H^c - \sum_{j=1}^{r} \hat{\gamma}_j w_j^2 (1 - H_j)}{1 - \sum_{j=1}^{r} w_j^2}$$

In this case s_i is redefined as the share of total employment in a group of r industries, the Herfindahl index H^c is now constructed from an aggregate level where $\left(H^c = \sum_j w_j^2 H_j\right)$, w_j is industry j's share of total employment in the r industries. H_j is industry j's Herfindahl index and $\hat{\gamma}_j$ is the value of the concentration index based upon the original specification for industry j. This analysis was conducted along with the original measure by Feser (2000).

His analysis is interesting and contradicts one important finding of the original Ellison and Gleaser (1997) work. One of the important findings from this initial work was about the level of spatial aggregation in the data. The authors are noted as saying that their statistic is robust to differences in the level of spatial aggregation in the employment data used to calculate the concentration index. However Feser (2000) found evidence when looking at a series of different aggregation levels that they generally do affect the statistic. He goes a stage further and recommends that sensitivity testing for alternative spatial units must be included with any detailed analysis comprising of a concentration measure. When utilising the co agglomeration statistic he finds it particularly susceptible to changes in aggregation. The research demonstrates that as the level of spatial aggregation increases the level of co agglomeration also increases.

The EG index has been utilised in many studies (Braunerhjelm and Borgman and Bertinelli and Decrop (2005) to name but a few). The model is not without criticism, a study by Head and Mayer (2004) using French data generates incredibly high industrial figures. This as noted by Bertinelli and Decrop is the result of one district. In particular the problem was created by the closeness of the region in question to the Switzerland border. This problem of spatial separation and aggregation is a continuous problem of concentration indices (Duranton and Overman, 2002). The aggregation of any spatial measures immediately results in independence from spatial restrictions. This is essentially treating space as being symmetric resulting in spatial autocorrelation issues Haining (2003). The other criticism levelled at the statistic is the lack of statistical significance Bertinelli and Decrop (2005). This stems from using employment data rather than plant count data, the latter being more accurate as estimation is rarely used, figures are based on counts or manufacturing census data (Guimaraes et al, 2007).

4.15. Alterations to the EG Index

Alteration to the EG index have been made by some authors. One of the most cited modifications comes from Maurel and Sedillot (1999) who examined the French manufacturing sector. Their model takes a similar specification to the EG model but differs in its relationship to the probability distribution of an industry. To explain the derivation it is required to consider the initial assumptions of the original model. If we look at the share of employment in a region i it can be shown that:

$$s_i = \sum_{j=1}^{N} z_j u_{ji}$$

Where N donates the number of firms and z1...zN the respective share of each firm in industry employment. The variable u_{ji} represents a form of dummy variable, i.e. if the firm j locates in area i, the value is 1 otherwise it is 0. u_{ji} can be thought of as non-independent Bernouilli variables Maurel and Sedillot (1999). It is then possible to derive the probability as:

$$p(u_{ji,} = 1) = x_i$$

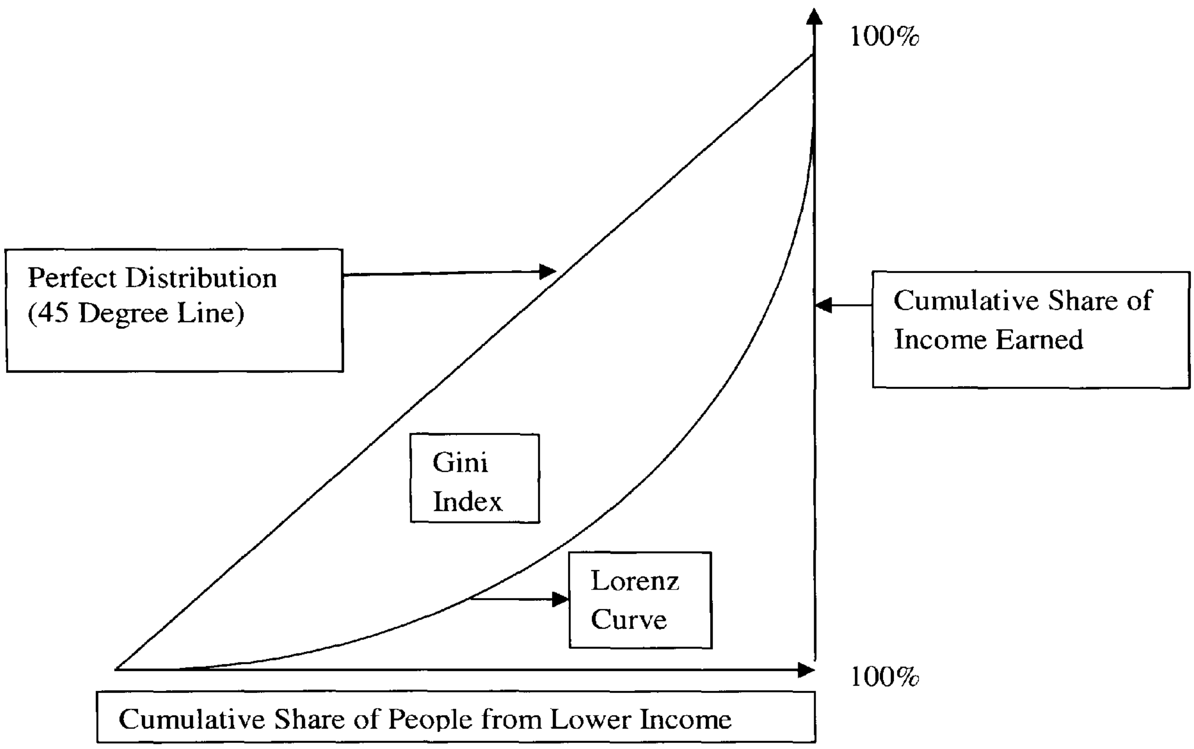
x_i is the share of manufacturing employment in industry i. This infers that the random location process in an area will on average replicate the employment patterns of the aggregate or in other words national patterns are found in all regions. The similarity with both indexes is that they take rather arbitrary cut off points i.e. (0.02, 0.05), this implies a lack of sophisticated statistical variance identification. Duranton and Overman (2002) start with the initial EG index but add a spatial distance measure.

This takes economic space as continuous thus negating the spatial autocorrelation as well as aggregation problems. They do this by computing the distance between pairs of plants in a particular industry then plot these distributions. The second stage of the analysis involves constructing confidence intervals for the local and global data. Its advantages are however contributable to two of its significant criticisms (Bertinelli et al, 2005).

The first is the issue of local spatial identity i.e. that ignoring the presence of political geographical borders does not allow for differing policies. This is to say target economic development policies are different in Wales then they are in other parts of the UK. The other problem noted is the specific data required in order to construct this framework, precise addresses of all producing firms are almost impossible to obtain from a national level from most developed countries. The Gini coefficient had been used a great deal in concentration studies since the early 1950's. The traditional work was pioneered by the research of James (1962) and was later added to by the work of Gastwirth (1972). But the origin of the statistic is far earlier, developed by mathematician Corrado Gini in 1912 it was used as a measure of inequality of economic distribution.

The traditional model is derived by utilizing a Lorenz curve Lorenz (1905) the model first constructs the traditional cumulative distribution function of a probability distribution See figure 35. The Gini index is the difference between the perfect distribution, and the Lorenz curve. If we convert the index into a coefficient a value of 1 would indicate a perfectly uniform distribution, whereas a value of 0 would imply perfect inequality in distribution. Its use in industrial concentration studies is much newer and work such as Kim (1995), Audretsch and Feldman (1996) have adopted the measure as a proxy in agglomerative studies.

Figure 16. Traditional Lorenz Curve



Wen (2004) constructed Gini coefficients' for multiple industries allowing the construction of an index of concentration. The formation of the statistic is as follows:

$$G_i = \frac{1}{2n^2\bar{s}_i}\sum_{k=1}^{n}\sum_{j=1}^{n}\left|s_{ij} - s_{ik}\right|$$

In this case the share of industry i in region j is given by s_{ij}, s_{ik} is the share of the same industry but in region k. n is the number of regions and $\bar{s}_i$ is the mean number of shares. As noted from traditional theory the Gini coefficient is equal to twice the area between a 45^0 line and the Lorenz curve. To begin the derivation this curve should first be calculated. This is done by ranking the share of industries across all the regions in descending order.

This is then plotted cumulatively on the vertical axis against the cumulative number of regions on the horizontal axis. This forms a traditional cumulative distribution line. It is noted by Wen (2004) that the more uniform the distribution the smaller the calculated index will be.

In this work value added data was used to derive the index. However previous work such as Crowley (1973) adopts a slightly different approach to the Gini calculation. He derives the coefficient by looking at the percentage of industries against the percentage of total employment, industries are again ordered in the same fashion except this time it is shares of regional employment. The Gini index has also been utilised by constructing it based upon location quotients. Amiti (1998) ranks the quotients in ascending order and plots the regional industry employment share against the national employment shares.

The problem with all these concentration indexes is the lack of consistency when it comes to a small number of firms within a particular industry. The reason for this is noted by Bertinelli et al (2005) is statistical. Any index that incorporates a Herfindahl style component and has few firms will result in the index tending towards one, and the denominator tending towards zero: consequently the overall result will go towards infinity. Studies such as Kim (2000) have tried to rectify this by deriving a threshold value for which the index is said to be biased.

The results of this work showed that, in an example where the industry is smaller than the number of spatial units, the EG measure is overestimated. Up to this point the literature explored has looked at implicit measures, but there are a wealth of explicit techniques, which have developed over the course of that last 50 years that try to tackle the issues of concentration in a different manner.

4.16. Explicit Measures of Concentration

One of the first of these measures is the work of Ripley (1970), later developed and added to by Besag (1977) and Diggle (1990). These statistics were designed with the principle of measuring clustering or dispersion under conditions of complete spatial randomness. The G measure was first utilised by Getis and Ord (1992) but was later transformed and augmented by Ord and Getis (1995), the statistic measures clustering or dispersion with regard to complete spatial randomness. The measure works by detecting patterns of spatial association in different areas. The flexibility of the measure is the fact that it can be used to measure concentrations across arbitrarily defined areas or administrative districts. This is in contrast to the EG statistic which identifies concentrations inside countries or counties as noted by Feser et al (2005). These same authors utilised the measure to look at industrial agglomerations in Kentucky in the United States. The statistic is calculated for a district i for a given industry, the measure is based on employment levels both in the area of study as well as those in the immediate neighbouring areas. This allows the identification of agglomeration across boundaries; this is where the traditional location quotient is inadequate, not being able to transgress over the given jurisdictions laid out from the start.

The formation of the statistic is as follows:

$$G_i^* = \frac{\sum_j w_{ij}x_j - W_i \bar{x}}{\sqrt{(nS_{1i} - W_i^2)/(n-1)}}$$

In this equation x is the aggregate employment within an agglomeration, $\{w_{ij}\}$ is a symmetric spatial weights matrix.

The matrix is used to define the relationship between the area of study and its neighbouring regions. It takes the form 0/1 where for region i $w_{ii} = 1$, W_i is the summation of the weights in $\{w_{ij}\}$ and $\bar{x}$ is the mean of agglomeration employment for the whole area under study or can be summarised as $\bar{x} = \left(\sum_j x_j\right)/(n-1)$.

The spatial weightings matrix is what allows the statistic to work so well, in the original work by Getis and Ord they utilise a simple rule in the construction of the binary adjacency matrix. Those areas including the region under study are assigned the weight of 1, those which are not direct neighbours of the region are given 0. When deriving the moments for the statistic Getis and Ord work under the assumption of normality. When the distance between areas is small, normality is lost, when the distance is great normality is also lost. Therefore for accurate use of the statistic, sample size is important.

Feser et al (2001) assume an approximate standard normal distribution, with 95% significance value of 1.96. A high value for G indicates the presence of positive spatial autocorrelation, this is the greater the value, the higher the amount of agglomeration.

Again like a great deal of the concentration indexes such as the Herfindahl, or Ellison and Glaeser's work, the G does not identify the factors behind the spatial concentration of industry but merely observes the agglomeration in action. The drawback of the statistic is also one of its given strengths, as noted by Feser et al (2001), the measure is essentially an inter-county concentration indicator. Then high values indicate that a given area is proximate to other areas with high concentrations of the particular industry under investigation.

The problem occurs if therefore one area has a great concentration and thus an agglomeration but none of its closest neighbours does, this will not be picked up by the G statistic. Smith et al (2007) note that the co-location element within the G statistic is the key element in any form of agglomeration study. This opens the debate as to what a significant concentration really is; traditional LQ measures would identify even the single area as a possible significant concentration of economic activity. This of course could argue for the need for multiple methodological approaches to examining concentrations. This being said the G statistic has been greatly used in regional economic research by authors such as Mitchell (2005), Wong (2006) and Helsel et al (2007) and has yielded some good results. Something to this point which has not been investigated is the notion of distance in spatial statistics, which from an intuitive point of view must be an important feature.

4.17. Adding Distance into Concentration Measures

One of the first measures to do this was the K statistic or function, first proposed by Ripley in his seminal work of 1977. This was later augmented by Besag's L function which as noted by Marcon and Puech (2003) is the more preferred measure. The K function is a tool designed to analyse spatial point patterns, or in other words the location of characteristics or events Ripley (1977). It is easy to see how the tool can be applied to industrial activity and in particular firm location and has been done so by Marcon and Puech (2003).

The underlying concept of both the measures (K and L) is the assumption of a random process resulting in the distribution of the point patterns. It is first step in applying either of these tools is to define the spatial distribution of the points (Ripley, 1976) or in the case of Marcon and Puech work, the firms. This is done simply by using coordinates (x, y). The density of the pattern is denoted by $\lambda(x, y)$. This density determines the probability given by the function F (dS), of the occurrence of a firm in an elementary area dS around (x, y). It is therefore possible to derive the value of F (dS) as:

$$F\,(dS) = dS.\lambda(x, y)$$

Assuming a random and homogeneous distribution, $\lambda(x, y)$ is now taken as a constant, the number of firms in an area, s is not. The number of firm is considered to follow a Poisson distribution, following from the idea that the process is random, the number of firms in an area is given by the parameter λs. It is essential to include the joint probability of the presence of two firms in two elementary areas, or $g((x_1, y_1), (x_2, y_2))$. These are centred on (x_1, y_1) and (x_2, y_2). The probability of this is given as:

$$P\,(dS_1,dS_2) = F\,(dS_1).F\,(dS_2).g\,((x_1, y_1), (x_2, y_2))$$

Work by Gereaud (2000) showed that the assumption of isotropy, all land is thought to be the same in every direction, is important within this form of distribution as distance is the variable of concern not heterogeneity of land. With this in mind g is only dependent on the distance r between groups of firms. This is noted and expressed by Maron and Puech as being g(r) or the pair correlation function.

The function F(dS) is considered independent from the position of other firms so $g(r)=1$. It is now possible to define what characterises a high concentration of firms.

Given the radius r, a relatively high agglomeration must see $g(r)>1$, this is to say the joint probability of the presence of two points is greater than the individual probability of just one firm existing at the given location. The terms geographic concentration can be used if the observed number of firms within a given locality is higher than that expected under the null hypothesis of a completely random distribution. If it is lower there is said to be geographical dispersion.

Ripley's (1977) K function describes the spatial distribution of a subplot the formation of which is expressed as:

$$K(r) = \int_{p=0}^{r} g(p) 2\pi p . dp$$

For each firm in the subplot, the number of them considered to exist in a circle with a radius r is $\lambda K(r)$. If we assume that $g(r)=1$ then the predicted points in circle r is $\lambda\pi r^2$, thus $K(r)=\pi r^2$. Given the aforementioned assumptions Ripley uses this value as a benchmark, as it is noted that $K(r)=\pi r^2$ is equivalent to $g(r)>1$. Therefore it is possible to determine the relative level of concentration by aggregating the number of firms on average next to each other in a circle with radius r. If there is an independent distribution of firms the number of neighbours will be $\lambda\pi r^2$, if there is a high level of concentration the number of neighbours will be greater than this value. If there is a lower value then dispersion is thought to be occurring.

The problem with this measure is the comparability of the radius. For different industries this value will change, thus comparing multiple industries becomes a laborious task. Besag (1977) normalized the function in order to obtain a benchmark no longer equal to πr^2 but instead equal to zero. Besag's L function is defined as:

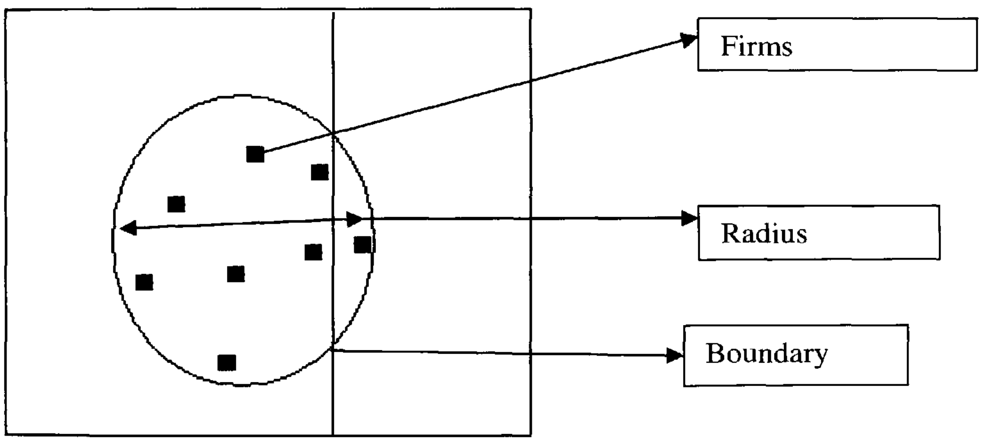
$$L(r) = \sqrt{\frac{K(r)}{\pi}} - r$$

L(r)>0 indicates a distribution which is geographically concentrated, while less than zero would indicate dispersion. L is homogeneous to a distance. Its value added to r is the radius of the circle. A circle has an equal number of firms that would be expected from a random distribution. To compute the L value a count needs to be made of each neighbouring points number in a given radius circle.

It is noted that both the L and K statistics have unknown distributions, thus calculating a variance is difficult Goreaud (2000). Therefore to aid in the process it is imperative to generate some form of statistical analysis of the value. To do this Goreaud (2000) proposed the utilisation of a Monte Carlo method thereby simulating a large number of homogeneous spatial distributions, having the same number of firms and density as the original sample. The precise number of simulations varies Marcon and Puech (2002) suggest in excess of 20,000 whereas Goreaud (2000) used 10,000. Marcon and Puech (2002) also introduced an important augmentation from the initial work by Besag. Due to the arbitrary nature of county boundaries certain points might be outside the area of study see figure 36.

The original formulation of the L statistic, would involve underestimating the number of points, this to allow for the fact that part of the circle will be outside the area being examined. This problem is referred to as edge effects. With this underestimation Marcon and Puech believed unnecessary bias was disrupting the results. To this end they propose looking at the circles partial area that is included in the study and correcting the number of neighbours by a factor equal to the whole circle divided by the study area. The only drawback as noted by the authors is the need for a precise coordinates of the boundary are required to calculate the edge effect.

Figure 17. Edge effects



This group of distanced based measures offer a very different approach to the study of agglomeration. The spatial dynamic is directly related to the distance function, this however can be problematic. Distance measures do not take into account boundaries be they man made or natural, thus the measures designed to limit modifiable areal unit problems (Openshaw and Taylor, 1979), often result in neglecting reality such as language differences or lack of infrastructure between regions Bickenbach et al (2006).

The existing measures mentioned in this chapter have a strong empirical focus and the criticisms of these frameworks comes from the lack of economic rational in some of these frameworks which have been stylised through mathematical endeavour rather than sound theoretical consideration. But it is the more theoretical focused measures such as the location quotient which have received equal criticism but from a lack of its accuracy in identifying levels of significance.

What both of the frameworks could benefit from would be the inclusion of some form of intra trade analysis. This would allow the capture of the important industrial linkages within an agglomeration rather than simply identify concentrations of industry.

4.18. A New Measure of Agglomeration

The existing specialisation measures critiqued in this chapter so far have been very much based upon statistical distributions as well as mathematically rigorous analysis.

This provides an excellent framework through which to establish an index about industries where little if any knowledge is known about the structures in place. Where this work seeks to be different is to construct a new index of agglomeration rather than concentration of specialisation, one not driven by statistical inference but by intuition as well as spatial economic theory. The LQ methods offers the ability to give much more detail regarding the shape of an industry as a whole in say, Wales, than is established simply by looking at the existing point estimates. The other area that needs to be incorporated into any new agglomeration statistic is intra industry trade. From the literature reviews in chapters 2 and 3 authors such as Porter (1998), Baptista (1998) and Grossman and Helpman (1994) emphasis the spillover of knowledge imply an importance in same sector relationships. Any statistic trying to capture the degree of agglomeration must incorporate these potentially imperative same sector trade relationships.

Literature by Markusan et al (1994) as well as Bergman and Feser (1999) has shown the diverging opinions as to what agglomeration actually is, with this in mind the use of proxy determinates offers a possible solution to the arguments rather than forcing a restrictive conformity upon the observable variables. Employment share statistics are used within the studies of De Propris (2005), Pickernell (2007). These gave a further understanding to the distribution of economic activity but fail in its most basic form to highlight significant sectoral dimensions, these could offer insight into the presence of agglomerations.

The use of 4-digit SIC data was chosen for this work to preserve the upmost detail regarding the specific industries being analysed.

What is proposed is to develop an index that can link together the sectors at a less disaggregated level. For example, SIC 15, manufacturing of agricultural foods is a composite of multiple sectors at the 4-digit level such as 1512, and 1513. The forms of significant concentrations being considered in this study follow the value chain style of agglomeration.

That is firms operating in the same sector but at different levels of the production process. This is not to say that this concentration of industry does not have inter-sector trade relationships but it is inferred for the importance of successful agglomerations that intra sector relationships are present. This is concentrations of industry which have the potential for firm spillovers, in terms of both knowledge and productivity benefits. For this index to be effective an assumption must be made that significant agglomerations of industry are made up of these intra trade relationships. What this work suggests is that agglomeration is the final phase of specialised sector concentrations. It maybe summarised by the phases below:

Table 7. Concentration and Specialisation Measures

Phase	Characteristic (Structure & Space)	Classification	Level of Aggregation for Identification	Statistic for Identification
1	Industries in the same location	Concentration	2 Digit	EG
2	Specialised Sectors	Specialisation	4 Digit	K or L or Gi
3	Concentrations of specialised sectors of an industry	Specialised Concentration	2&4 Digit	LQ or Amended EG
4	Attributes of both the other phases, but also an interaction between these sectors	Agglomeration	2&4 Digit	C

To this point agglomeration has been used to describe all of the above phases in different pieces of work, see Porter (1998), Markusan et al (1994). For the first time this research wishes to establish a distinction between these phases. It suggests that agglomeration is only present if there is a statistically significant build up of industry in a location, which results in the specialisation of industry and finally interaction between these sectors.

The first phases of this are unremarkable and may result because of the localisation of factor inputs or some other location specific advantage. However highly agglomerated industries in the third phase, will be more efficient in terms of output than industries which are spatially segregated. This is important and implies that agglomeration has a positive effect on the performance of industrial sectors. The other important assumption is that agglomerations of industry have significant interaction amongst the firms, which share the same area of economic space. The question of interaction causes a number of problems within the domain of empirical economic analysis. Traditional benefits of agglomeration come from human interaction (Swann et al, 1998), knowledge spillover effects being a good example of this; this is an individual firm learning from what others are doing.

To measure these effects causes a great difficulty for researchers. The method utilised by many studies has been to distribute questionnaires to firms who have been identified through some means of statistical test as being part of an agglomeration such as the study of Langford et al (2004) cited Wolfe et al (2004).

4.19. Input Output Analysis

The framework and establishment of an index within this work will avoid the problems of questionnaires highlighted in work such as Brusco (1992) by looking at some form of proxy for the interaction information. Input output tables were first conceived by Wassily Leontief, the founding father of Input-Output analysis in (1963) a work for which he won the Nobel Prize in 1973. Input output tables allows the estimation of financial transactions of an economy for a particular time frame. Input output tables are actually based upon the use of a matrix to show the different sectors of the economy and their relationship to one another in terms of their purchasing and sales patterns Brand et al (1998). The importance and the value of the framework can be summarised in the following terms:

> *"Each economic system – even that of an under-developed economy – has a complicated internal structure. Its performance is determined by the mutual relations of its different component parts, just as the motion of the hands of a clock are governed by the gears inside. Over the past 25 years the internal economic gear-work of a large number of countries has been described with increasing clarity and precision by a technique known as inter-industry analysis, or Input-Output analysis".*
> (Leontief, 1963, pp162-163).

The precise workings of the table are complex but are derived from very simple algebraic expressions that represent the economy as a set of linear equations.

It is possible to explain the transactions matrix with a very simple example. X_{ij} is the sale between industry i, and industry j, Y_i is the final demand and Z_i is the total sales of an industry. It is now possible to derive a formulation for an industry's output, this is given by the following identities:

$$X_{11}+X_{12}+X_{13}+X_{14}+X_{15}+X_{16}+Y_1 \equiv Z_1$$
$$X_{21}+X_{22}+X_{23}+X_{24}+X_{25}+X_{26}+Y_2 \equiv Z_2$$
$$X_{31}+X_{32}+X_{33}+X_{34}+X_{35}+X_{36}+Y_3 \equiv Z_3$$
$$X_{41}+X_{42}+X_{43}+X_{44}+X_{45}+X_{46}+Y_4 \equiv Z_4$$
$$X_{51}+X_{52}+X_{53}+X_{54}+X_{55}+X_{56}+Y_5 \equiv Z_5$$
$$X_{61}+X_{62}+X_{63}+X_{64}+X_{65}+X_{66}+Y_6 \equiv Z_6$$

This can be summarised using matrix algebra:

$$Z_i \equiv \sum_j X_{ij} + y_i$$

In the above formulation Σ_j is the summation of all industry in sector i over all industries j. To derive the intra industry trade figure from the above formulation one simply takes a diagonal of the matrix above this is. X_{11}, X_{22}, X_{33} Etc. This is the trade taking place between the same industries. To derive a coefficient, to ascertain the ratio of intra trade compared to total trade, X_{11} is divided by Y.

.

In order to establish the level of interaction amongst industries within the same sector the domestic use matrix can be utilised. The matrix provides figures on expenditure between firms in different sectors (inter) and between firms in the same sector (intra). To make use of this information this work suggests using these coefficients to provide a way of capturing one of the primary agglomeratory effects, trade between same sector industries. The higher the value the greater the extent of the trade compared to inter sector purchases. This implies that firms do more trade with those in same industries rather than outside of it.

4.20. The C Statistic

The next important step in forming an index of agglomeration (which we will call the C statistic) is to measure the relative strength of an industry or the specialisation it has within a given region. To do this it was considered that instead of focusing on the distribution, for example a normal distribution as in the Ellison and Gleaser statistic, this work will examine the relative specialisations of industry across Wales TTWA's by using the traditional LQ formulation from a two digit SIC level.

For each TTWA, each industry will then be broken down into LQ>1 and LQ<1. The aggregated employment value for each of these groups (expressed as a percentage of total employment in that industry) will then be subtracted from one another. This generates the specialisation differential. What is being determined by doing this is the degree of both specialisation (industrial) as well as concentration (regional) of any given industry.

The final part of this analysis is to weight the specialisation differential coefficient by the degree of intra regional trade. This is achieved by multiplying it by the intra trade coefficient. This is derived from input output tables by simply calculating the proportion of total domestic inputs for each industry which are derived from within this industry.

The resulting value to be known as the C statistic reports both a combined value of specialisation, concentration and trade, there by a proxy for the illusive force of agglomeration. This will now be shown mathematically. The equation of the C Statistic is formed by first calculating the specialisation differential for industry i in region r , ψ_{ir}, this can be derived as:

$$\psi_{ir} = \frac{\left(\sum EMPi \in \left(\frac{\frac{xi}{ni}}{\frac{x}{n}} \right) > 1 \right)}{\sum_i EMP_i} - \frac{\left(\sum EMPi \in \left(\frac{\frac{xi}{ni}}{\frac{x}{n}} \right) < 1 \right)}{\sum_i EMP_i}$$

This differential is then multiplied by the industry i intra trade coefficient γ to calculate the C statistic, this maybe expressed as:

$$C = (\psi)\gamma$$

The statistics by looking at the dimensions of both specialisation and intra trade captures not simply concentration, but agglomeration.

The higher the value the greater the degree of intra trade within the concentrated industries. Due to the formulation it is possible to have a negative value for the C statistic thus meaning a negative agglomeratory force in the industry, similar to the centripetal forces described by Krugman (1998). An industry which has a high C statistic is said to be exhibiting a high degree of agglomeratory force.

4.21. Summary of Agglomeration/ Cluster Measurement

After considering both spatial and concentration measures available for the detection of clusters or agglomeration it maybe rightly questioned, which is the best method? This is not an easy question to answer and often different methods when applied in differing data sets give different results. More fundamentally different statistics are actually measuring different things, e.g. the LQ measures specialisation and the EG measures concentration yet both are considered as forms of cluster analysis by different authors. What is important to understand is spatial scale. When designating a cluster of a particular industry the spatial scale that one chooses to define is almost as important as the definition of a cluster itself. This work has tested this notion by looking at different spatial scale, the UK and Wales and using the LQ technique applied to 2 digit industry data. The goal of this exercise is to evaluate if there is any significant difference in result when defining different spatial areas. An operation issue, but yet no less important, is the choice of denominator used in LQ calculations. The review of the technique in this chapter considered the theoretical construction of the tool and its uses, but what has not been looked at, to this point, is the choice of data to input into the calculation. It is important now to consider the use of LQ denominator values and their effect on specialisation results.

4.22. Spatial Denominators in LQ Calculations

This work has used the traditional LQ formula without too many worries over consistency or accuracy, based upon the extensive use of the formulation in preceding work. One issue over its formulation, however, has yet to be tackled and that is the use of the denominator value. Within most studies such as the DTI report and the work of Flegg and Webber (1996) the denominator is not a issue as the UK aggregate was used to establish the relative significance of an industry. However, due to the focus of this work on Wales, the choice of the denominator could be a more complex issue.

The use of the UK figure increases the spatial dimension of the data being examined, yet the goal of this work was to establish what the spatial agglomerations within Wales are. This means any increase in the denominator should theoretically reduce the amount with one exception; that is if the national ratio is significantly less than the local ratio. In this scenario, it can be questioned which is the correct figure to use. The point being, do we choose to count the Welsh manufacturing sector as a single entity or do we treat it as a component of the much larger UK sector? The obvious geographical similarity and national government albeit with an Assembly in Cardiff would suggest segregation is not a valid option. However, this research has shown the differing economic structure in place in Wales compared to the rest of the UK. With greater concerns in manufacturing the country could be seen as being more sensitive to changes within industry as opposed to other parts of the UK. Therefore, this research sets out now to ascertain whether changing the denominator from a UK figure to a Wales figure significantly changes the results of the LQ technique.

The other area of interest would be to establish if having different size TTWA's alters the value when choosing between these denominators again. In theory a large TTWA should weaken the effect of any specialisation of one specific industry; that is to say, the ratio of one industry to all industry in a large TTWA should not be greater than that in a relatively smaller area. To answer these questions poised LQ's were calculated for all the 2 digit manufacturing sectors, i.e. SIC 15 to SIC 36. Three TTWA's were chosen each with differing working population sizes, Aberystwyth 400, Swansea 9182, and Pontypridd and Aberdare 1836. Table 8, 9 and 10 give a breakdown of the results, and charts 18, 19 and 20 provide a graphical representation.

Table 8. Comparison of Wales Vs UK LQ Small

Small:Aberystwyth	SIC 15	SIC 18	SIC 20	SIC 21	SIC 22	SIC 26	SIC 28
UK Emp	415439	41174	75140	77690	320556	109929	323329
Wales Emp	22910	1494	4056	5042	9424	5442	16885
Welsh LQ	3.22407	1.688197	2.220842	0.142923	6.002608	1.32418	0.106695
UK LQ	3.096616	1.066881	2.0879	0.16155	3.073524	1.141717	0.097043
Small:Aberystwyth	SIC 29	SIC 31	SIC 32	SIC 33	SIC 34	SIC 35	SIC 36
UK Emp	277899	120429	68760	113541	185950	139862	166487
Wales Emp	11665	9183	7609	5672	13229	11055	12119
Welsh LQ	0.308881	0.039237	0.047353	1.334009	0.190654	0.097777	0.683812
UK LQ	0.225816	0.052109	0.091265	1.160666	0.236234	0.134605	0.866939

Table 9. Comparison of Wales Vs UK LQ Medium

Medium: Swansea	SIC 15	SIC 17	SIC 18	SIC 19	SIC 20	SIC 21	SIC 22
UK Emp	415439	85975	41174	11202	75140	77690	320556
Wales Emp	22910	2901	1494	240	4056	5042	9424
Welsh LQ	1.076587	0.693106	4.076005	0.398949	0.722357	0.334224	1.227326
UK LQ	1.034027	0.407324	2.575891	0.148867	0.679115	0.377782	0.628429
Medium: Swansea	**SIC 24**	**SIC 25**	**SIC 26**	**SIC 27**	**SIC 28**	**SIC 29**	**SIC 31**
UK Emp	199872	199595	109929	73976	323329	277899	120429
Wales Emp	10354	12296	5442	12281	16885	11665	9183
Welsh LQ	0.839665	2.102462	0.763588	1.529655	1.38362	0.832303	2.139543
UK LQ	0.757578	2.255836	0.658371	4.422843	1.258457	0.608477	2.841447
Medium: Swansea	**SIC 33**	**SIC 34**	**SIC 35**	**SIC 36**			
UK Emp	113541	185950	139862	166487			
Wales Emp	5672	13229	11055	12119			
Welsh LQ	0.354496	0.285166	0.048502	0.818505			
UK LQ	0.308432	0.35334	0.06677	1.037702			

Table 10. Comparison of Wales Vs UK LQ Large

Large: Pontypridd	SIC 15	SIC 17	SIC 18	SIC 19	SIC 20	SIC 21	SIC 22
UK Emp	415439	85975	41174	11202	75140	77690	320556
Wales Emp	22910	2901	1494	240	4056	5042	9424
Welsh LQ	0.542492	0.874126	2.646057	0.522273	0.244853	0.810828	0.452223
UK LQ	0.521047	0.513706	1.672214	0.194885	0.230196	0.916499	0.231552
Large: Pontypridd	**SIC 24**	**SIC 25**	**SIC 26**	**SIC 27**	**SIC 28**	**SIC 29**	**SIC 30**
UK Emp	199872	199595	109929	73976	323329	277899	29229
Wales Emp	10354	12296	5442	12281	16885	11665	907
Welsh LQ	1.248782	2.208181	1.041801	0.110701	0.75377	1.223328	1.679638
UK LQ	1.126699	2.369267	0.898248	0.320081	0.685583	0.894346	0.907767
Large: Pontypridd	**SIC 31**	**SIC 32**	**SIC 33**	**SIC 34**	**SIC 35**	**SIC 36**	
UK Emp	120429	68760	113541	185950	139862	166487	
Wales Emp	9183	7609	5672	13229	11055	12119	
Welsh LQ	1.795467	0.923774	1.327641	0.282794	0.784092	2.339087	
UK LQ	2.384493	1.780421	1.155126	0.350402	1.079421	2.965501	

Figure 18. Comparison of Wales Vs UK Denominator Small TTWA

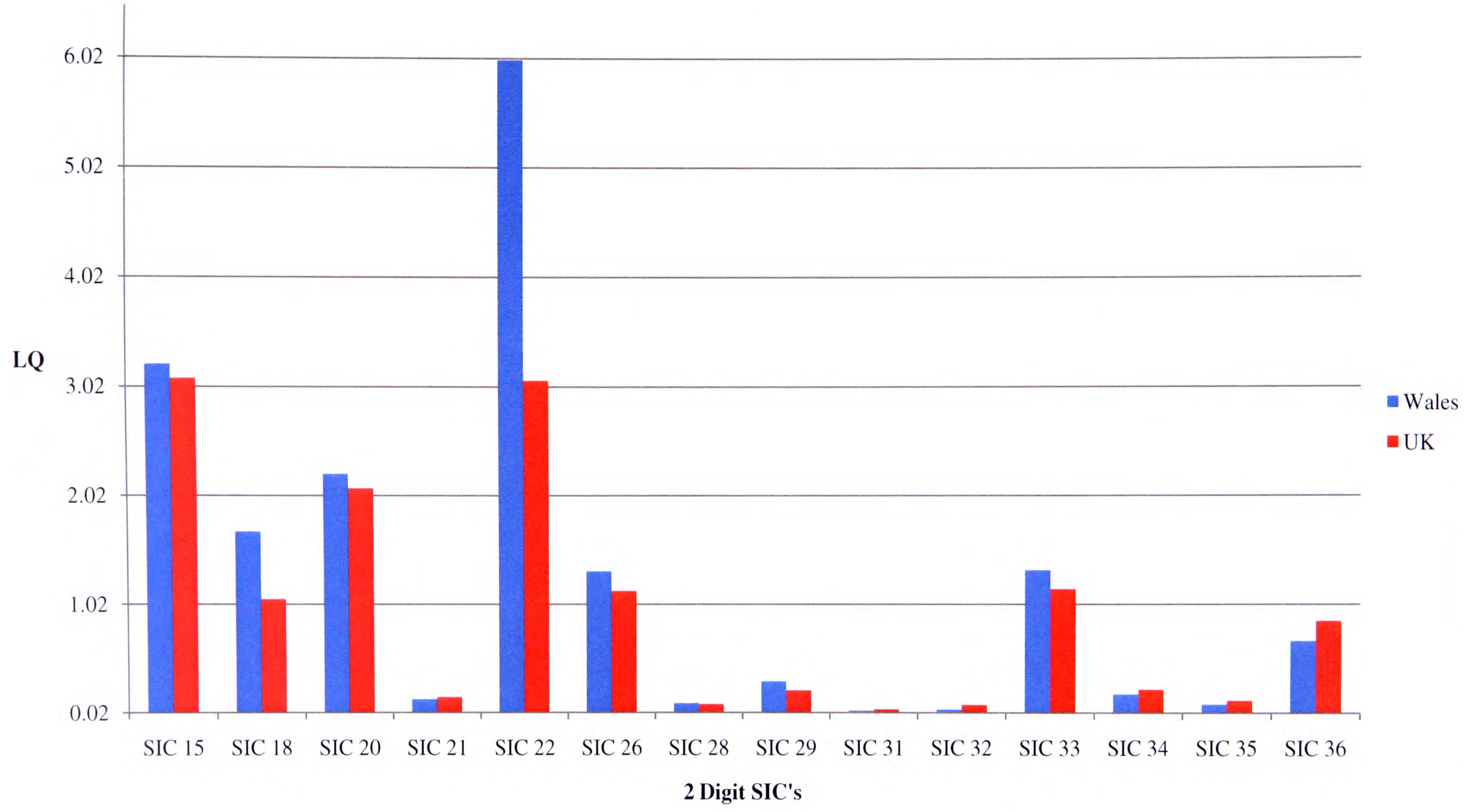


Figure 19. Comparison of Wales Vs UK Denominator Medium TTWA

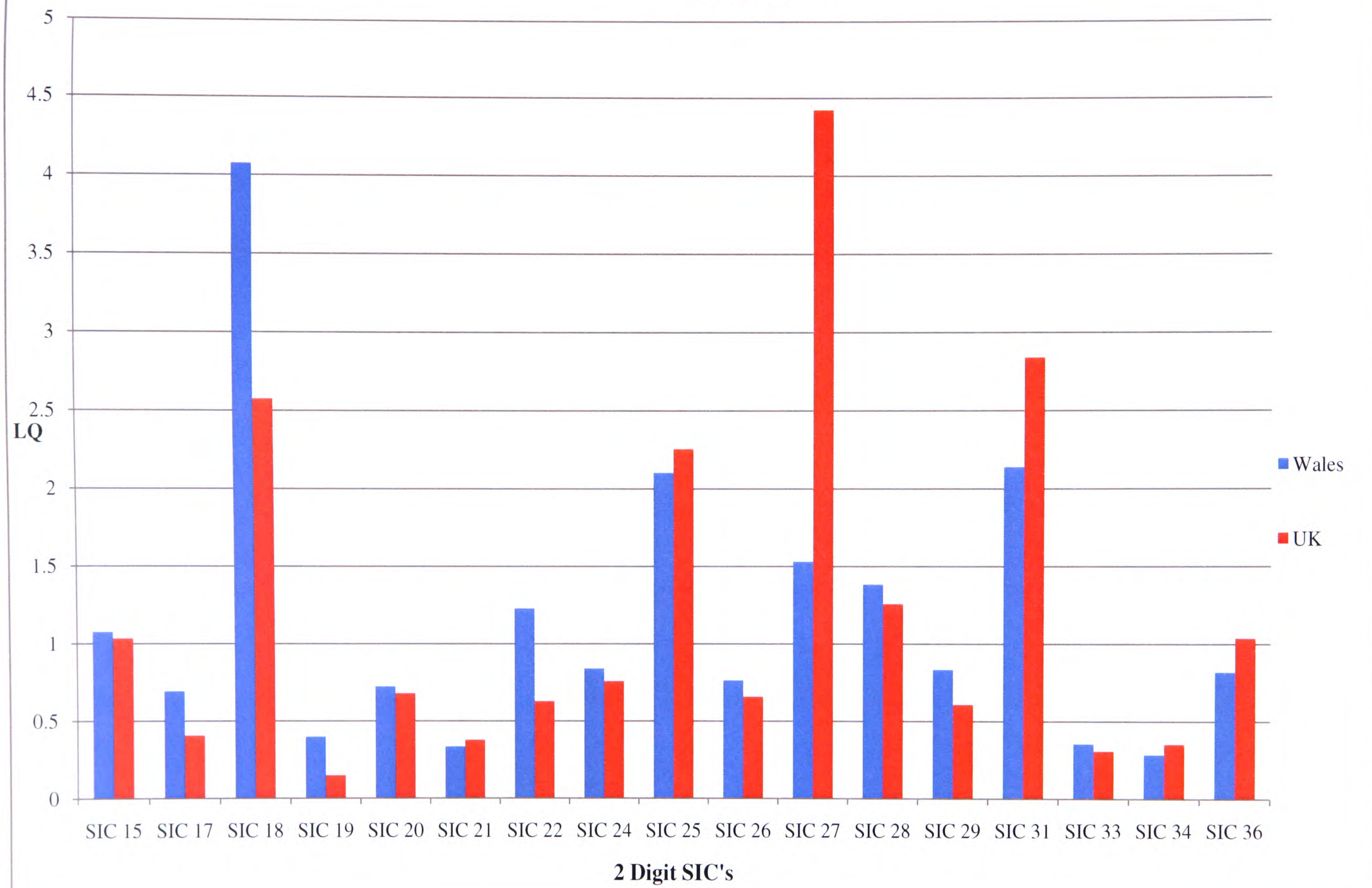
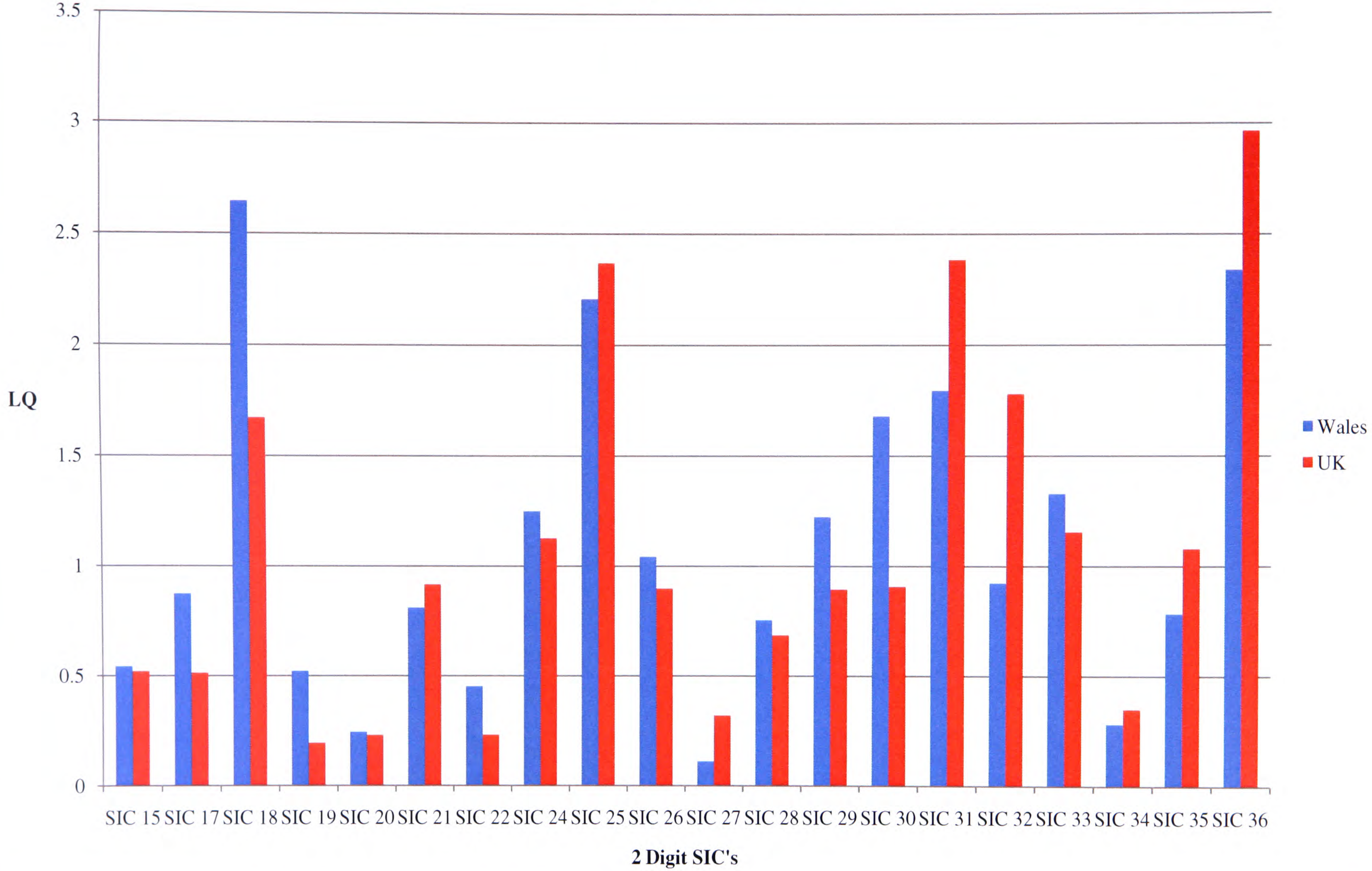


Figure 20. Comparison of Wales Vs UK Denominator
Large TTWA



The results of this analysis are intriguing and raise some more questions regarding the choice of a denominator in this form of LQ technique. The first being the differences between the two sets of data in particular within the smaller TTWA's. This is not unusual but the possibly unexpected result is the larger LQ value obtained when using the UK denominator.

The results show that out of the sample used for this research, the difference between using a UK denominator and a Welsh denominator is significant thus changes the bearing of the results. However, significance has not been the basis for the interpretation of the LQ figure up to this point. Indeed, government sponsored research in the UK e.g. (DTI report 2000), used an arbitrary cut off point of 1.25 to determine if a sector was significant. What is even more disturbing to note from these results is the over representation derived in smaller industries by using the UK denominator, for example SIC 36 in all of the small areas. In the relatively large TTWA's of Pontypridd, 5 industries yielded greater LQ values by using a UK denominator. This research has shown a significant problem with the use of different denominators in the construction of confidence intervals. Therefore, further research must be conducted on this measure to ascertain the reasoning behind these differing results.

One thing must be noted though and that is the lack, to this point, of statistical assessment in the dissemination of LQ values. Like all academic tools credibility and bias elimination must be the priority of the researcher.

After looking at these results this research would suggest that the choice of denominator is vitally important in spatial economic analysis of clusters. This research would advise the use a UK denominator. By using a UK denominator specialisations found are relative to the whole UK economy.

If a smaller spatial scale was used, for example Wales, the specialisations found would only be relevant to that particular open economy. It can be questioned if this is justifiable. One may hypothesise that the best denominator would be one that encompasses the whole world because this would identify the actual distribution of industry within a completely closed system. This is an impossible figure to establish in reality, because of data and definitional difficulties. Thus, one must look for the largest possible and practical spatial scale which allows a fair substitute to a completely closed system. By using the UK denominator it is hoped to give a truer reflection of the specialisation in Wales.

4.23. Conclusion

This chapter has examined a vast amount of literature on measuring economic clusters. Multiple methods encompassing many different techniques have been appraised, from highly statistical methods to more intuitive LQ techniques. What has come through by looking at these different techniques is the multiple attributes of industrial clusters. Some of these measures such as the EG index consider industry to have a normal distribution and compare deviation to this assumption. Other work such as the L statistic considers distance as a primary attribute to be used as a comparative for identifying concentrations of industry.

One of the most important things to emerge from this research is the notion of specialisation and concentrations, being used interchangeable to this point, as being unique phenomenon. When using different statistics, the choice, should be based upon a specific definition of a cluster rather than on data constraints. To this end this work wishes to apply the De Propris multi procedural method to a case study region in order to assess the usefulness of the approach. This work also wishes to now employ the confidence interval method to this data in order to ascertain any improvement to LQ estimation.

The research would also seeks to employ the new C statistic on the case study region to gage it usefulness in identifying agglomeration rather than clusters. The technique will be appraised against an existing measure, the EG index.

Chapter 5: Results 1: Spatial Concentrations of Manufacturing in South Wales

5.1. Introduction

The initial chapters of this work have explored the concepts of spatial economics, with particular attention focused on agglomeration and as some authors have referred to clustering of industry. In order to develop this work further, theory must give way to evidence; hence this work will look for evidence of agglomeration in the economy today. The mammoth task of analysing in detail, the whole of a country such as the UK is not feasible. Therefore, it has been decided that taking a region as the area of study provides a much more manageable task as well as allowing a more detailed investigation. In order for any such analysis to take place, it is essential to understand the economic background to the region being investigated and consider the temporal spatial economic distribution. This work will now apply the methodological approach developed by De Propris (2005) in order to identify spatial concentrations of manufacturing in South Wales. However, where this work is distinctive from previous work, is the level of disaggregation in the data used. Large scale studies such as the De Propris work used 2 digit SIC data to calculate specialisations of industry. This study will use 4 digit SIC data as well as the multi-procedural approach adopted by De Propris (2005). It is these two key factors which will provide a framework to begin an agglomeration analysis.

However, it must be emphasised at this point, it is the researchers contention that the term clusters, considered in chapter 3, is not applied to any of this sections findings, as agglomeration is still the focus of the investigation.

Previous work of this nature in South Wales has been conducted with varying degrees of success. The largest study was that conducted by the DTI (Department of Trade and Industry) in 2001. The report entitled "Clusters a First Assessment" was an interesting starting point in agglomeration analysis, however the results painted a rosy picture of clusters within Wales. The report, although conducted on a national basis, took to reporting the findings on a region by region approach. A fundamental issue that is not raised in the report is the methodological approach used. The project was based on the theoretical and empirical work carried out by Michael Porter of the Harvard Business School Competiveness Research Group. They used location quotients calculated from 5 digit SIC data to identify industries considered to be clusters. The threshold value chosen was the traditional 1.25 (please refer to chapter 3 discussion on the LQ technique); other criteria included employment in the specific sector. It was decided upon that for a cluster to be considered "a high point" for a region, 20% of employment should be in the sector concerned. However, the report did not examine to any real extent, some of the more important cluster notions such as intra industry trade as well as growth implications. (Some of the findings of this report will be discussed in more detail later in this chapter

5.2. Agglomeration and South Wales

As noted in previous chapters the perceived benefits of agglomeration and the noted criticisms are typically taken as a given. Nevertheless, this work will now attempt to both identify and to an extent quantify the agglomerations in this region. It must be also be noted that the denominators chosen will be the UK aggregates.

The emerging work of the new economic geographers such as Fujita and Thisse (2000), and Mills and Hamilton (1994) outlined throughout the previous chapters, highlight the importance of spatial proximity to the productivity of industry. The need of firms to interact effectively can create a strong form of attraction for firms operating within similar industries. Oerlemans and Meeus (2005), after analysing many different forms of inter-firm cooperation within the Netherlands, declared significant productivity benefits can exist for firms operating within a similar locality, as they experience so-called agglomeration economies.

Current methods of assisting manufacturing, in particular in Wales, have focused on financial support. One problem encountered with this form of development is the notion of "footloose capital". Firms who are attracted by financial aid can subsequently move on when that aid dries up, or when other regions are able to offer even more of an incentive to locate there. It may be that, in order for financial assistance to be a more reliable tool for economic development, firms should be encouraged to operate within areas with existing concentrations of similar industry. Peterson (1980) points to the importance of local government support and concurs that it has become somewhat of a necessity within regional development.

However, this view is not shared by all. Later works by Appold (2004) as well as Bondonio and Engberg (2000) contradict this and find mixed evidence to support government intervention.

5.3. The 2001 DTI Cluster Report of Wales

It was important, before beginning this research, to examine the findings of this report in particular focusing on the sectors highlighted and the relative significance identified, in terms of the regional economy. The study focused on all parts of the economy utilising a simple rule: if a sector has an LQ greater than 1.25, then immediate attention is drawn to these areas, which are then highlighted together, in an attempt to understand the extent of the clustering of activity.

Then an ad hoc approach is used to match up other sectors associated with these "high points". This was then followed by a qualitative session of discussions with local authorities in the regions of the UK to get their input into the clusters present. The problem with this form of study is the lack of initial data analysis taking place, in particular the lack of firm size analysis as well as concentration analysis, which is a major flaw when attempting to understand economic clusters. Table 11 provides a summary of the manufacturing clusters identified in Wales.

Table 11. 2001 DTI Summary of Welsh Clusters

Sector	Age	Employment	Significance
Aerospace	Established	Declining	International
Automotive	Established	Stable	National
Biotechnology	Embryonic	Growing	International
Clothing	Mature	Declining	Regional
Industrial Equipment	Established	Stable	Regional
Metal processing	Mature	Declining	Regional
Opto Electronics	Embryonic	Growing	International
Plastics	Established	Stable	Regional
Toys	Mature	Declining	Regional
Furniture	Mature	Declining	Regional

The DTI results show that three manufacturing sectors are considered internationally significant: aerospace, biotechnology and the Opto electronics industries. Overall the summary for Wales is that it is a highly specialised economy with 49 "high points" and 151 industries in which Wales is over represented, i.e. having an LQ greater than 1.25.

However, given the notion of over 20% of the regions employment needing to be in one sector for it to be clustered, Wales, according to the report is not strongly clustered.

The narrow definition of what a cluster is according to the DTI, means that Wales appears to be under-represented in the Porterian view of a cluster. Having said all this a more substantial issue does arise with the work by the DTI and that is their use of the LQ technique. In the methodological section of the report it clearly states that the LQ "...is a standard measure of concentration". It goes on further to explain that it is a relative measure that can describe the concentration of either an industry or sector. This is at pains with the work of McCann (2001), as well as Traistaru (2002), who both emphasise the use of the LQ technique as a measure of specialisation rather than concentration. This seemingly minor difference has a knock on effect in the ability of the work to say it is focusing on concentration when the major tool employed is a measure of specialisation. The report gave some insight into the current agglomerations thought to be present within Wales but the differences in both definition as well as measures mean that little more than a cursory comparative is possible with the potential findings of the research. The sectors reported in table 9 are national clusters for Wales and it will be interesting to see if the same sectors are identified using the methodology of this work.

5.4. The Goals of This Analysis

This chapter sets out to examine the spatial distribution of economic activity in South Wales. At this point, it is imperative that we define what is being looked at within this study. Geographical concentrations of industry have received a great deal of attention within regional economic studies, proliferated by the work of the Harvard cluster mapping project lead by Professor Michael Porter.

These studies focus rightly on both the concentrations as well as interactions of industry. This thesis does not set out to, clarify the existence or otherwise, of clusters, but intends to examine the existing spatial distribution of industry within South Wales.

It is important to declare at this point, that no comment is made over the possible interaction of these industries, although this is a relevant topic in future research. It was decided to focus the attention of the work on the manufacturing sector rather than looking at services or the whole economy. This has been chosen for two primary reasons; when looking through the vast survey material from the previous chapter a reoccurring problem was noted over the forms of industry being contrasted.

This is to say heavy manufacturing and digital service prevision. To avoid this sectoral variation error, the manufacturing industry is being concentrated on, which will give giving a fairer comparative analysis. The other reason for this choice of sector is its relative importance in South Wales historically.

Due to the historical background of the region it was considered that a temporal analysis be employed for the first two types of analysis of the De Propris methodology. This will be done by examining the locations where manufacturing had a relatively large presence in 1998 compared to the figures for 2004. The dates were chosen for a significant reason. With the election of a Labour government in 1997, came the establishment of a devolved Assembly in Cardiff.

This government was given control over regional economic decisions in particular, with its agenda focused on developing an economy for the 21st century. This work seeks to deepen the understanding of local industrial structures. The measurements chosen in this study provide empirical support for the intuitive argument set out by authors such as Markusan et al (1994), linking firm size and firm agglomeration. Additionally, studies such as Sforzi (1990) have remarked that firm size plays a prominent role in the performance of the manufacturing sector.

Traditionally, models examining manufacturing productivity and growth (such as Baldwin and Picot (1995)), have found that small firms out perform their larger rivals. Contrary to this view Baldwin (1996), concludes, after utilising new statistical methods, that large firms can be the natural engines for manufacturing growth in the long run.

Armstrong (2001) adds to this debate, through case study analysis pointing to the importance of SME's (Small to Medium size business Enterprises) in providing a strong support structure to large corporations. For the present research, both sector and firm size in South Wales have been examined in detail and new maps developed to illustrate dominant areas of manufacturing compared to the service industries, as well as the size of those firms making up the manufacturing sector.

To give more insight into change over time, figures for 1998 are compared to those for 2004. The last two types of analysis of the De Propris methodology utilises the traditional location quotient method to identify specific industrial sectors which will produce a map of manufacturing concentration levels in the region. The other procedure in the methodology is to examine both firm size and industrial concentration at the same time. One of the fundamental difficulties in spatial economic research is that of geographical boundaries. For this work, South Wales has been delineated in terms of Travel To Work Areas (TTWA). This approach has been followed by Dewhurst and McCann (2002) and by De Propris (2005).

The advantage of this delineation is the absence of overlaps within the data sets, which can sometimes happen with the use of county or regional fixed boundaries. Other advantages of TTWA's as spatial units of analysis, include make-up and derivation. The definition of boundaries is based upon approximations of self-contained labour markets relating to the numbers of people commuting to work. This approach allows an accurate delineation of areas consistent with factor mobility.

Table 12 overleaf outlines levels of employment in the 18 TTWA's that make up South Wales between 1998 and 2004. The data shows the general trend of falling levels of manufacturing employment in almost all of the TTWA's, with the notable exceptions of Brecon, Merthyr, Pembroke, and Pontypridd.

Table 12. South Wales TTWA Employment levels 1998 and 2004

TTWA's	*Total workforce 1998*	*Manufrg 1998*	*Total workforce 2004*	*Manufrg 2004*
Brecon	9,495	781	9,788	811
Bridgend	50,773	15,252	55,638	11,647
Cardiff	203,695	26,818	241,943	20,180
Cardigan	5,878	856	6,388	588
Carmarthen	15,745	793	23,040	779
Cwmbran and Monmouth	44,600	12,811	44,847	9,622
Fishguard and St David's	2,736	479	2,981	178
Haverfordwest	15,650	1,615	18,967	1,264
Lampeter	5,173	828	5,920	684
Llandeilo	2,680	539	3,156	306
Llanelli	18,972	4,888	21,235	4,045
Merthyr	17,633	3,453	22,261	4,603
Neath and Port Talbot	38,855	12,823	37,526	9,027
Newport	89,508	20,071	95,476	15,144
Pembroke and Tenby	9,256	1,274	10,104	1,285
Pontypridd and Aberdare	72,465	16,844	78,370	18,212
Rhymney and Abergavenny	54,823	17,294	59,025	14,695
Swansea	98,051	13,849	115,199	9,143
UK Level	**24,354,983**	**4,039,508**	**26,024,705**	**3,074,881**

The Standard Industrial Classification (SIC) is the international system used to analyse industrial sectors based upon common production processes. "The classification provides a framework for the collection, tabulation, presentation and analysis of data and its use promotes uniformity. In addition, it can be used for administrative purposes and by non-government bodies as a convenient way of classifying industrial activities into a common structure" ONS (2007). There is criticism of this methodology, for instance, Mackay (1999) notes there is a lack of consistency in data collection methods. Despite this, it has been decided to use this data as it is the best available information for this work.

There are of course differing definitions of manufacturing. Some studies include agriculture, (Sforzi 1990, De Propris 2005) although this is a complicated sector to examine via location quotients because of the predominance of sole traders, whilst many independent units mean cross-sector influences. To this end, agriculture is excluded from this work. Manufacturing sectors as defined within this work make up around 11% of UK GDP.

5.4. Multi Procedural De Propris Methodology

It has been stressed in this work that the term cluster is perceived to be linked to simply one Porterian view of the phenomenon. This view negates the temporal dimension to cluster development, in that a cluster must be in existence for the methodological approaches to identify the significance of a particular sector.

However, the problem with this form of analysis, is the fact that sectors which may not be agglomerated at this point, may still have all the characteristics present but not at a significant level. The other issue, as discussed in De Propris (2005), is that of emerging production systems in developed nations and embryonic industries in developing countries. The author noted that methodologies which are inductive, that is clusters are observable, may fail to identify concentrated industries if these are at an embryonic stage. This would therefore surely limit the opportunity of policy makers to support and exploit product niches, or sub sectors of industries. Where the De Propris methodology is unique, is that it looks at the underlying characteristics of clustered industries both in terms of specialisation and firm size. The paper defines a cluster in terms of a local production system or LPS. Where this work really succeeds is in the very general definition employed.

As seen from the previous chapter one of the major problems of agglomeration study is the vast number of definitions typologies and varying classification systems. This makes it incredibly complicated to compare agglomerations identified across multiple study areas. De Propris says that LPS's are "... the geographical agglomeration of firms specialized in one or a few complementary sectors". This highlights the traditional characteristics seen within the early work of Marshall, which are again present within this style of methodology. LPS's are said to have an external division of labour, and there is also the inclusion of some concepts spoken about in great depth by (Cooke and Morgan, 1998), concerning more or less developed social capital in a region, as well as a more or less engaged institutional framework.

The inclusion of these two elements is interesting and is a qualitative element in the descriptive statistics associated with measuring agglomeration. For the purposes of this work it has been decided to employ only the first half of the methodology outlined in the paper. This has been done for two reasons. The first is, the choice of data set of this present research. 4 digit industry data has been opted for as opposed to the 2 digit class used in the original work. This has been done to establish the agglomeration of specific sectors rather than simply industries. It was thought agglomeration should be analysed from the sector to the industry in order to capture the specialisation component often neglected within research using aggregated industrial data. For instance, if we simply take the manufacturing sector there are 21, 2 digit sectors that make up these industries. However, when we turn to 4 digits manufacturing is broken down into 240 sectors. This massive differential is both beneficial but also problematic.

Having such precise detail on individual sectors offers the opportunity to determine with a greater precision the exact industrial agglomerations present. However, the problem with such a large data set and level of disaggregation, the accuracy of the data must be questioned. Upon first examination of 4 digit SIC data there are a large number of zero's for some small industries. After further analysis there is little problem with using the data set when the assumption is made that the aggregated UK figure given by Nomis is correct[3].

[3] After discussions with NOMIS it was found that all SIC data is estimates rather than counts. Using 4 digit data statistically is no less accurate than 2 digit or 3 digit.

The second reason for only implementing the first part of the methodology are the objectives behind conducting qualitative research. The De Propris work wished to examine the forms of inter firm relationship that existed between those areas said to have agglomerations. It is not the intention of this work at this point to attempt to answer such a complex question, rather it looks to understand why inter-firm relationships are key in explaining the presence of agglomeration.

It is also clear from investigating the literature that the extent to which these relationships exist is vastly diverging between sectors. This means the use of case studies on a data set (for all Welsh manufacturing sectors) may be divisive. In particular, the insights gleaned may not offer any greater understanding than that achieved from the spatial diagnostic. Therefore, the goal of this thesis is to conduct an in-depth initial analysis of manufacturing agglomeration in South Wales so as to understand the distribution of economic activity today.

5.5. Commentary of the De Propris Criteria

Table 13 shows the employment share of Manufacturing for specific South Wales TTWA's in 1998 and 2004. Those marked by an asterix (*), indicate an area that is relatively manufacturing intensive compared to the UK as a whole. Table 13 overleaf, shows that half of the South Wales TTWA's had relative concentrations of manufacturing in 2004, whilst in 1998, 11 of the 18 areas were relatively manufacturing intensive.

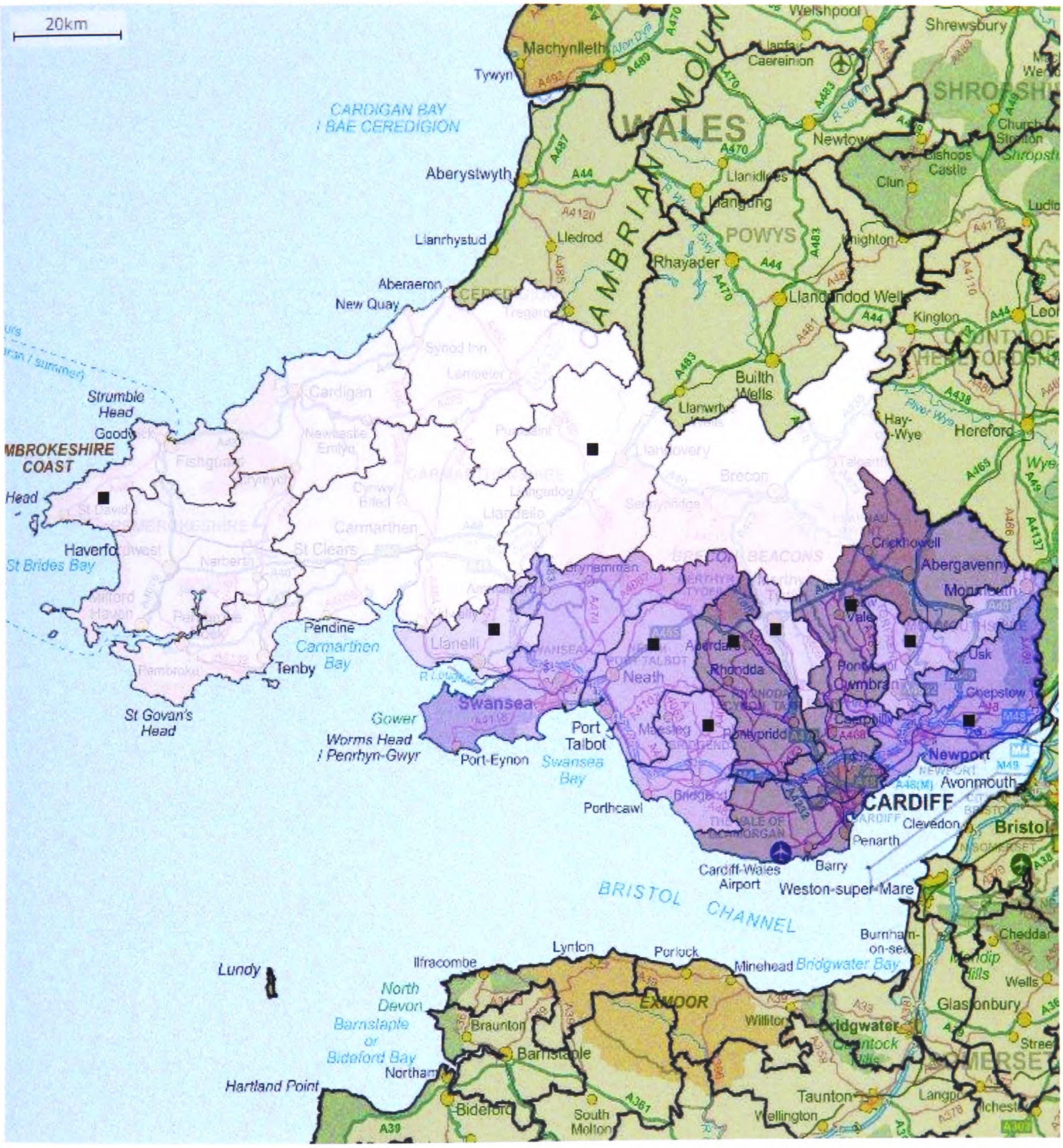
Figures 21 and 22 show the absolute numbers employed in manufacturing in each TTWA (hence Cardiff, the largest TTWA, has the darkest shade), whilst the data points identify relative high concentrations of manufacturing employment. Interestingly Cardiff, despite the highest number of manufacturing employees, has a relatively low share of manufacturing in total employment.

Table 13. Manufacturing Share

TTWA's	*Share1998*	*Share2004*
Brecon	0.082	0.083
Bridgend	0.300*	0.209*
Cardiff	0.132	0.083
Cardigan	0.146	0.092
Carmarthen	0.05	0.034
Cwmbran and Monmouth	0.287*	0.215*
Fishguard and St David's	0.175*	0.06
Haverfordwest	0.103	0.067
Lampeter	0.16	0.116
Llandeilo	0.201*	0.097
Llanelli	0.258*	0.19*
Merthyr	0.196*	0.207*
Neath and Port Talbot	0.33*	0.241*
Newport	0.224*	0.159*
Pembroke and Tenby	0.138	0.127*
Pontypridd and Aberdare	0.232*	0.232*
Rhymney and Abergavenny	0.315*	0.249*
Swansea	0.141	0.079
National Level	**0.17**	**0.12**

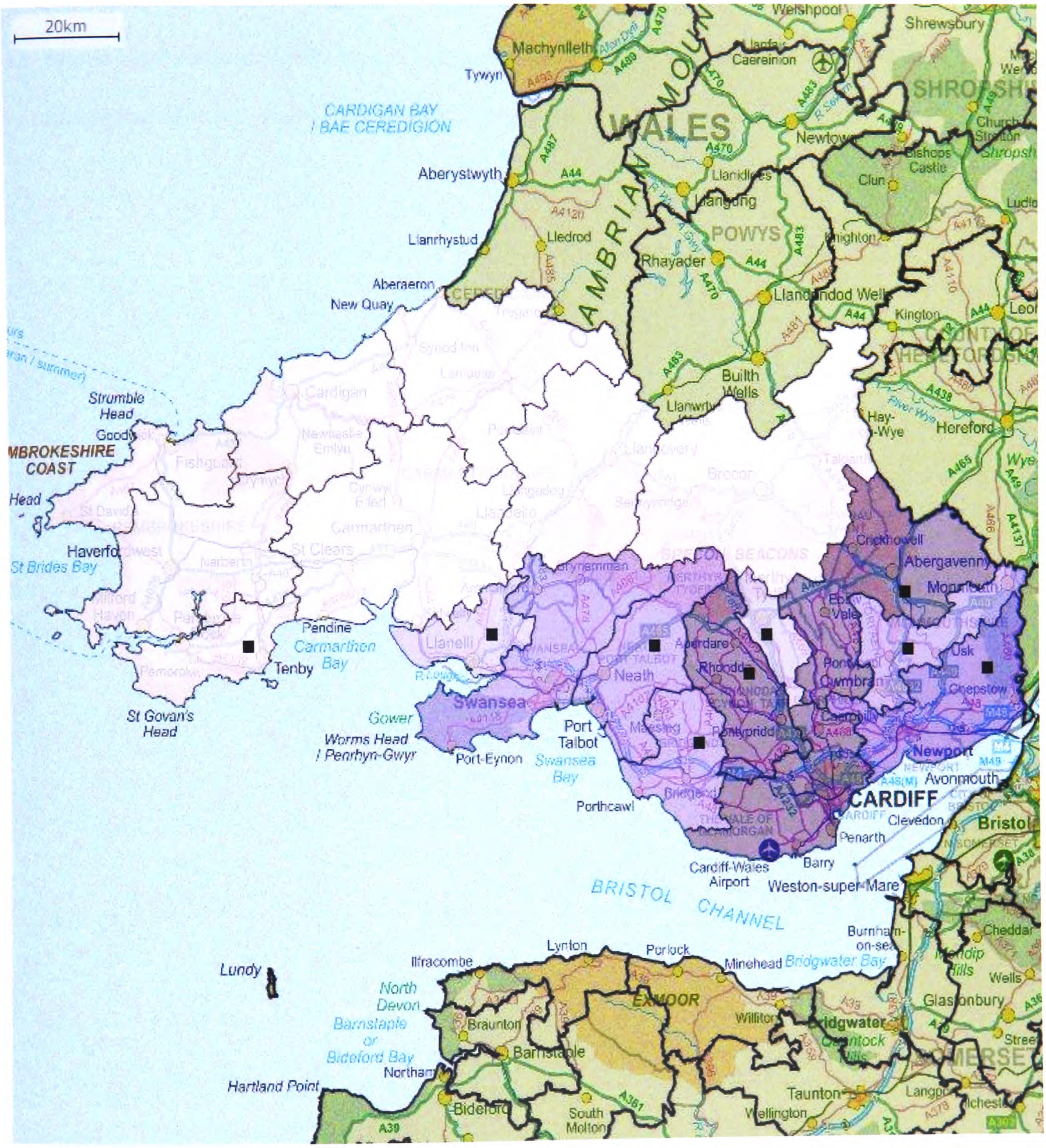
* = Manufacturing Intensive

Figure 21. Manufacturing Intensities 1998



■ = Manufacturing Intensive

Figure 22. Manufacturing Intensities 2004



■ = Manufacturing Intensive

The next stage in this work was to focus on those areas identified as manufacturing intensive and look at their composition in terms of firm size. Figure 23 and 24 display the results for the concentrations of small, medium and large firms engaged in manufacturing for each of the periods being examined.

Figure 23. Firm size values 1998

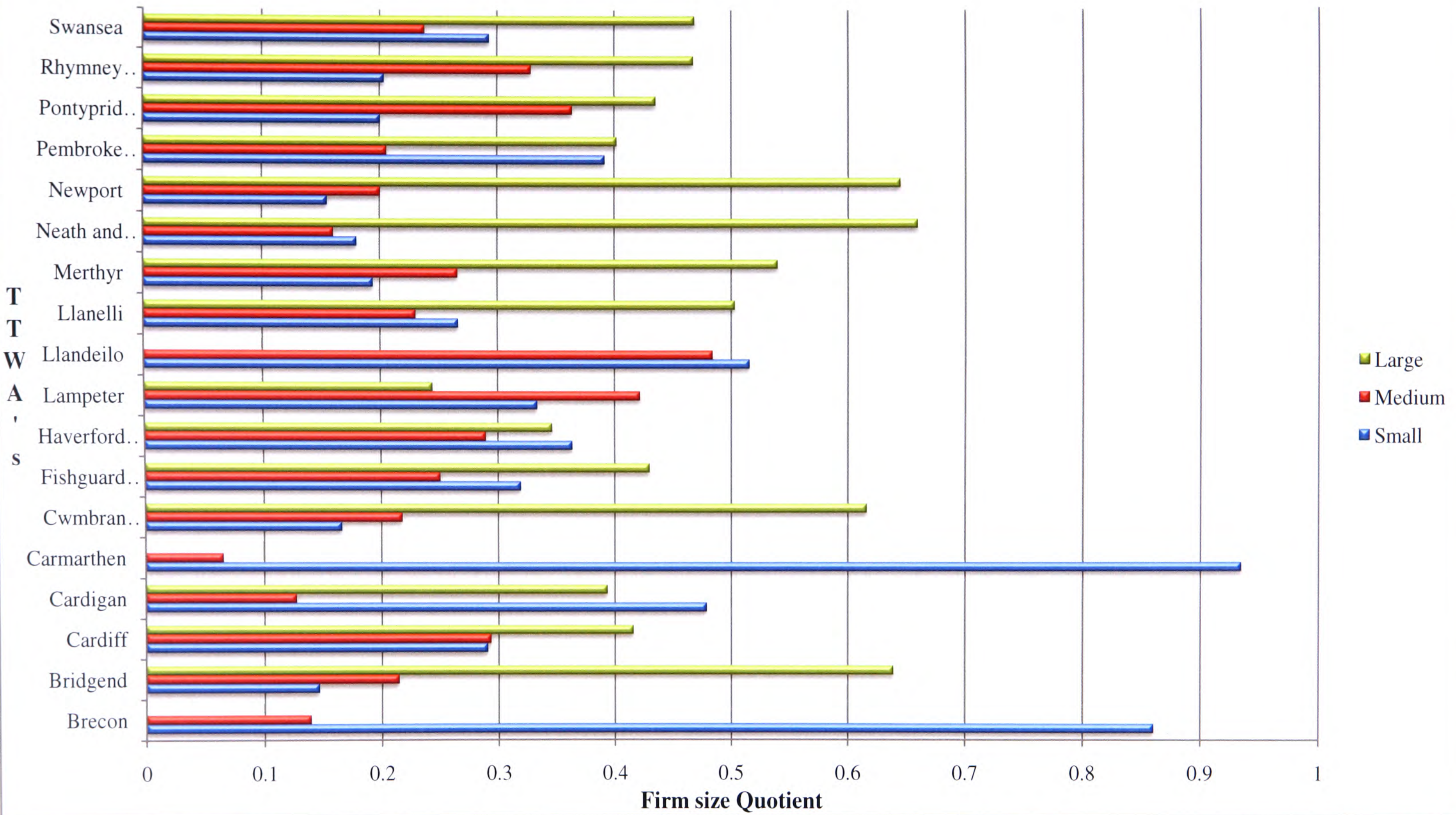
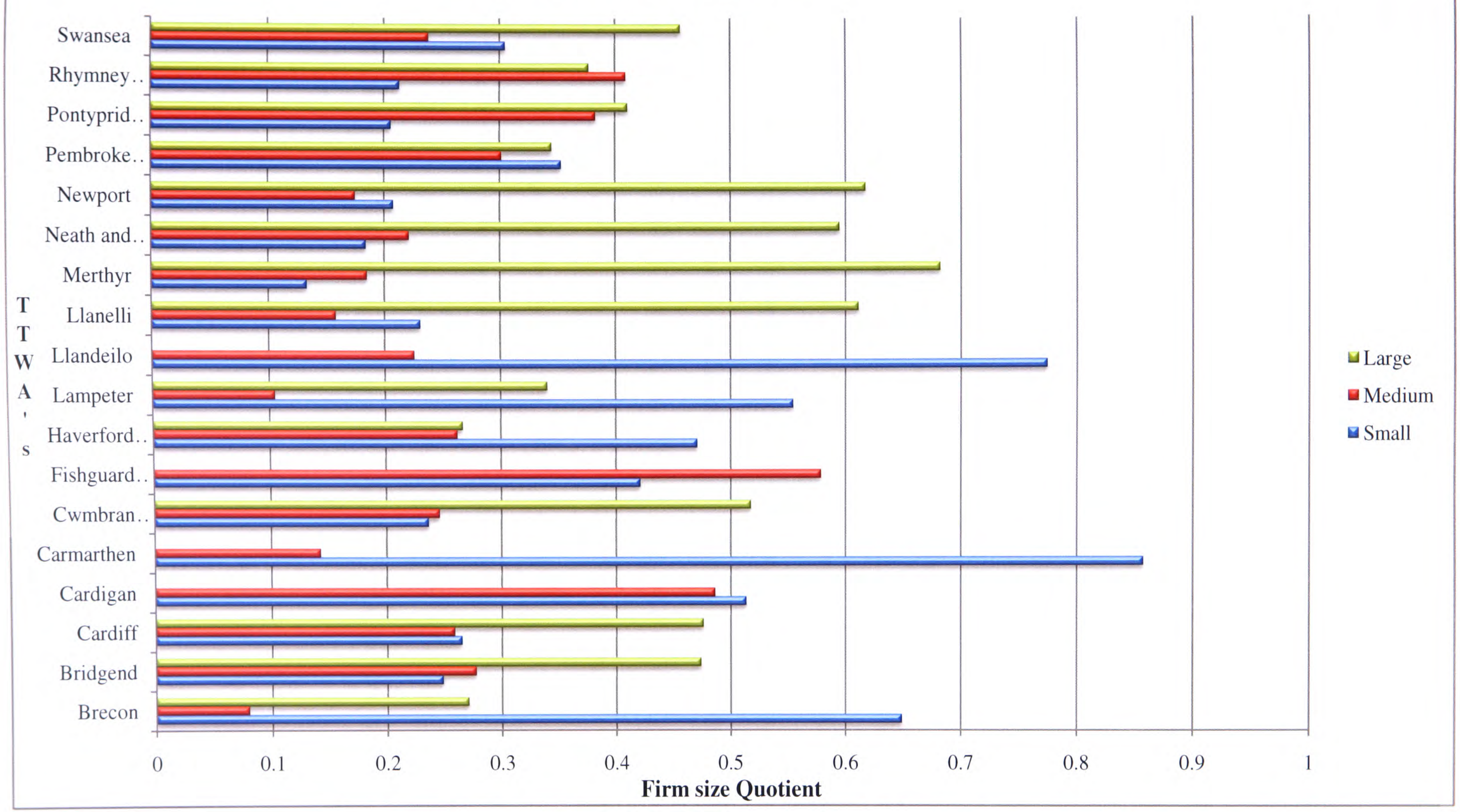


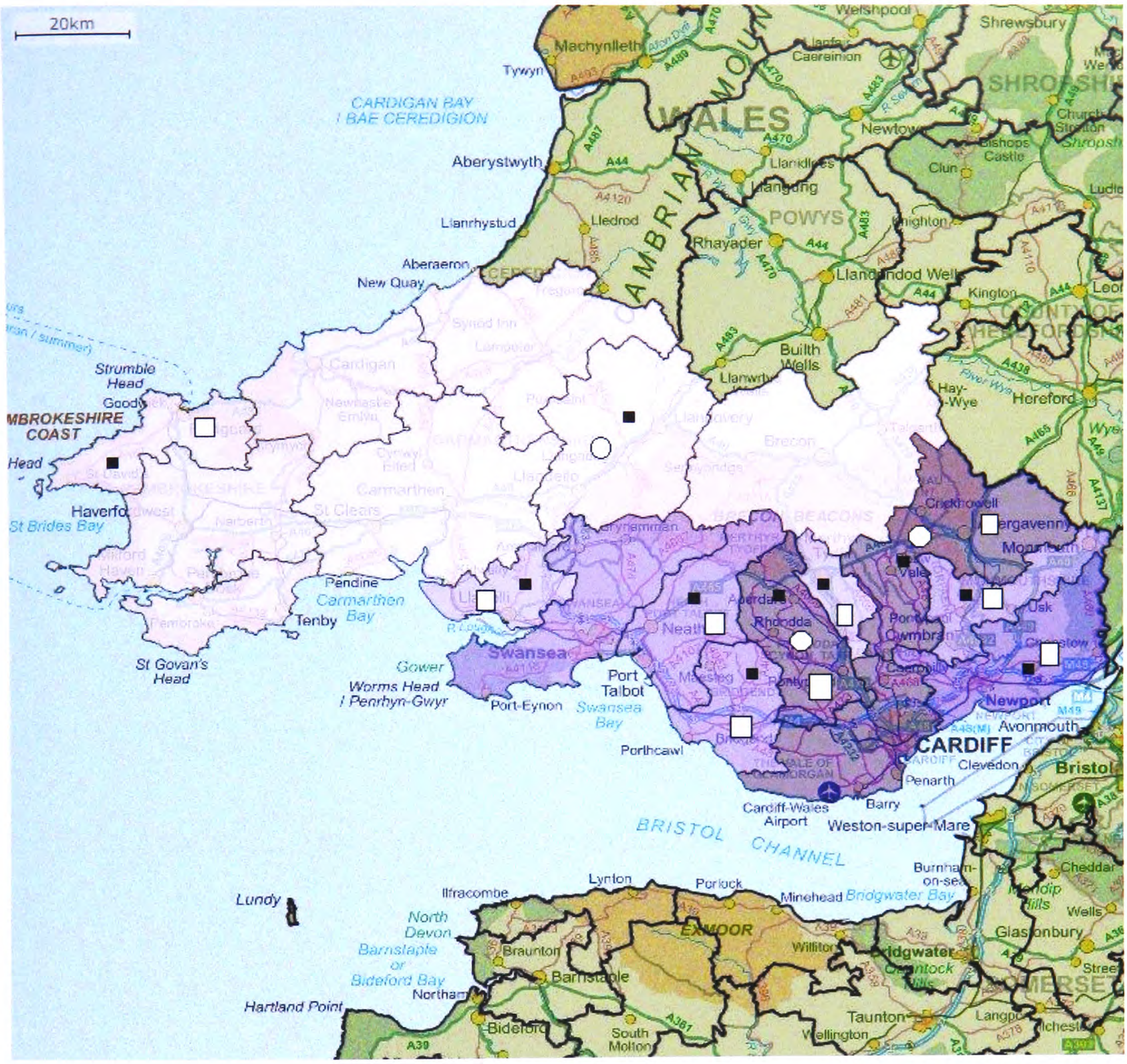
Figure 24. Firm size values 2004



The first point to underline is the spatial dispersion of small and medium size firms, regardless of whether a TTWA has a high concentration of services or manufacturing. However, areas with a relative intensity in manufacturing tend to be dominated by large firms. Three South Wales TTWA's have both a high intensity of manufacturing and large concentrations of medium and large firms (Bridgend, Pontypridd, and Rhymney). This finding is interesting and corresponds to patterns seen in some other European countries over the last two decades see the work of (Gert–JanHospers & SjoerdBeugelsdijk (2002)) who discuss the structure of European clusters.

Baden- Wurttemberg in Germany for instance is one of the most prosperous regions in Europe, with that prosperity based around large businesses creating linkages with many medium sized enterprises operating within close proximity (Cooke and Morgan, 1998). These forms of relationship offer strong advantages to firms and have been linked to increased regional growth (Ciccone, 2002). The seeds of such relationships within Wales should therefore be of keen interest to the Welsh Assembly Government and it's the Department of Economy and Transport (DE&T), as these areas could provide the starting point for possible inter firm linkages, or agglomerations. This has been confirmed by researchers such as Fujita et al (2002), who have found such linkages can help create large-scale national growth and act as drivers of innovation and change.

Figure 25. Firm Size and Manufacturing Intensities 1998

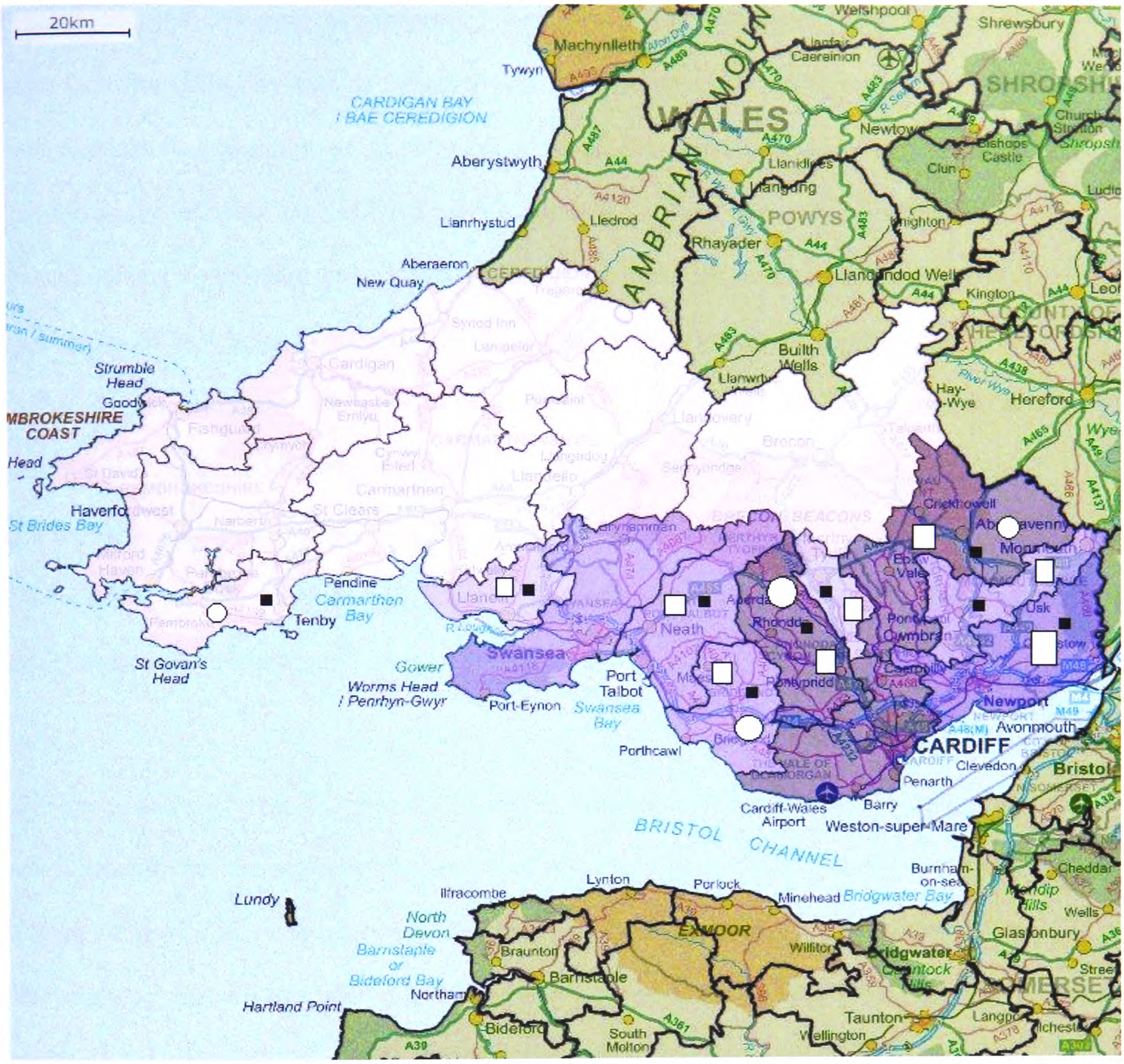


■ = Manufacturing Intensive

○ = Medium Firm Intensive

□ = Large Firm Intensive

Figure 26. Firm Size and Manufacturing Intensities 2004



■ = Manufacturing Intensive

○ = Medium Firm Intensive

□ = Large Firm Intensive

Figures 25 and 26 give a comprehensive picture of the spatial distribution of manufacturing firms by size in South Wales and may provide some insight into the new economic geography of the region. One of the most intriguing points to of interest is the increase in SME's between the two periods. Whereby, in 1998 large manufacturing businesses dominated the areas of intensity, a more diverse picture appears in 2004, where a more profound change is seen by the fall in the number of manufacturing intensive TTWA's in the region. If a distance is considered it is possible and rather telling that the geographical spread of industry has halted over the last 6 years. However, the original manufacturing heartlands, such as Pontypridd and Newport are still the core of the industrial activity and if anything have reinforced their position of strength.

The next stage of the analysis is to move from the very general, in terms of manufacturing to the very specific. The work will use 4 digit industry data to calculate the LQ values for the manufacturing sectors in South Wales based upon data for 2004. The temporal method has been decided against in this element of the work due to the nature of the calculation; a point estimate, as well as the vast data being examined. When investigating the specific industries through an LQ, no question of time or degree of accuracy, is included as it merely measures against what is present. This study has moved away from determining what clustering is to now questioning how to find it. The first two measures of the De Propris methodology provide trends for comparison of the region, although the usefulness of measuring comparative LQ's across time is problematic.

An increasing LQ value for a sector in one region may not be an indication of increased specialisation but merely the result of industrial decline. This subtle yet important difference means the notion of temporality is not an accurate measuring of increasing specialisation.

To this end this study will simply use the traditional LQ formulation and establish from the 240 manufacturing sectors being examined, which are significant in the 18 TTWA's that make up South Wales. For this initial stage of the analysis it was decided to utilise the DTI cut off point of 1.25 as the threshold value of significance.

This is not a rounded endorsement of that method or the measure but simply as a form of consistency. Table 14 is an example of the results for one of the TTWA's: Carmarthen. Table 15 gives a summary of the number of sectors being calculated as being significant in all the TTWA's. For the full results for all the TTWA's please see the enclosed data disk.

Table 14. Location Quotients Carmarthen

SIC	*LQ>1.25*
1552 : Manufacture of ice cream	2.32
1571 : Manufacture of prepared feeds for farm animals	68.7
1572 : Manufacture of prepared pet foods	67.41
1581 : Manufacture of bread; manufacture of fresh pastry goods	2.26
1584 : Manufacture of cocoa, chocolate and sugar confectionery	1.45
1589 : Manufacture of other food products not elsewhere classified	5.47
1598 : Manufacture of mineral waters and soft drinks	4.64
1712 : Preparation and spinning of woollen-type fibres	3.29
1722 : Woollen-type weaving	8.96
1730 : Finishing of textiles	13.61
1752 : Manufacture of cordage, rope, twine and netting	3.12
1810 : Manufacture of leather clothes	17.49
1822 : Manufacture of other outerwear	3.95
2010 : Saw milling and planing of wood, impregnation of wood	17.01
2030 : Manufacture of builders carpentry and joinery	2.59
2212 : Publishing of newspapers	1.34
2215 : Other publishing	3.08
2221 : Printing of newspapers	49.57
2231 : Reproduction of sound recording	4.99
2512 : Retreading and rebuilding of rubber tyres	25.58
2523 : Manufacture of builders ware of plastic	9.68
2621 : Manufacture of ceramic household and ornamental articles	1.33
2625 : Manufacture of other ceramic products	3.54
2852 : General mechanical engineering	2.21
2924 : Manufacture of other general purpose machinery	3.13
2932 : Manufacture of other agricultural and forestry machinery	28.29
2943 : Manufacture of other machine tools not elsewhere classified	1.99
3210 : Manufacture of electronic valves and tubes	2.01
3310 : Manufacture of medical and surgical equipment	7.23

Table 15. LQ's for TTWA's

TTWA	*LQ > 1.25*
Rhymney	49
Pontypridd	52
Lampeter	29
Llandeilo	26
Llanelli	29
Merthyr	22
Neath	27
Newport	39
Cwmbran	32
Fishguard	16
Haverfordwest	26
Cardigan	22
Cardiff	58
Brecon	26
Swansea	40
Carmarthen	33
Bridgend	38
Pembroke	20
Average	***32.4***

When examining the De Propris results, using 2 digit data, 5 to 8 industries appear to be significant within a TTWA. When using a much more disaggregated data (In table 15) set the numbers of sectors highlighted rises. On average each area has almost 33 sectors per TTWA which have a greater specialisation than the UK level.

Some areas such as Pontypridd and Cardiff have 52, and 58 respectively. Does this indicate that there could be this many clusters within such small spatially confined areas? This criterion has failed to really distinguish industrial specialisation at this level and offers little in categorising agglomerations present in South Wales. One finding that could be drawn from these results is the level of specialisation in the region. The measure is unable to distinguish how specialised these sectors are, however, it has shown the extent to which TTWA's do have a concentrated sectoral focus.

The final measure in the De Propris methodology attempts to capture what size firms are involved in the specialisation of the industry. This is a crucial aspect of agglomeration to look at, as seen in chapter 3, firm size appears to be an important determinate in both defining and explaining the functioning of agglomeration. The results are displayed in Table 16, for a full breakdown of all the results see the enclosed data disk.

Table 16. Pembroke Criteria 4 Output

* Dominated by	Small	Medium	Large
1551 : Operation of dairies and cheese making	*		
1552 : Manufacture of ice cream	*		
2212 : Publishing of newspapers	*		
2213 : Publishing of journals and periodicals	*		
2214 : Publishing of sound recordings	*		
2215 : Other publishing	*		
2224 : Pre-press activities	*		
2320 : Manufacture of refined petroleum products	*	*	
2523 : Manufacture of builders ware of plastic	*	*	
2663 : Manufacture of ready-mixed concrete	*		
2852 : General mechanical engineering	*	*	
2862 : Manufacture of tools	*		
2912 : Manufacture of pumps and compressors	*		
2924 : Manufacture of other general purpose machinery	*		
3511 : Building and repairing of ships	*		
3512 : Building and repairing of pleasure boats	*		
3520 : Manufacture of railway and tramway locomotives	*		
3550 : Manufacture of other transport equipment	*		
3614 : Manufacture of other furniture	*		
3663 : Other manufacturing not elsewhere classified	*		

In the TTWA of Pembroke, there are no large firms involved in any of the specialisations, and the majority of the industries are formed from small firms. Yet, three industries, SIC 2320, 2523 as well as 2852, indicate a strong presence of agglomeration of both medium and small firms in these industries. Without looking at the other criteria 1-3 it is hard to establish whether these agglomerations are significant or not.

It was decided that due to the large number of sectors identified by criteria 3 that instead of focusing on specific industries this work would utilise the De propris methodology and simply identify the forms of agglomerations that are found in each of the 18 TTWA's (Table 17 overleaf).

Table 17. Summary of De Propris Methodology

Agglomeration	**Carmarthen**	**Cardigan**	**Haverfordwest**	**Lampeter**	**Swansea**	**Llandelio**
Pre-district						
LPS small firms						
LPS medium/large firms						
Specialised sectors outside of industrial district						
LPS of large firms					x	
None Manufacturing LPS	X	x	x	x		x
Agglomeration	**Llanelli**	**Fishguard**	**Pembroke**	**Rhymney**	**Newport**	**Cardiff**
Pre-district						
LPS small firms						
LPS medium/large firms				x		
Specialised sectors outside of industrial district						
LPS of large firms	X	x			x	x
None Manufacturing LPS				x		

****LPS= Local Production Syste**

The decision not to look at the individual agglomerations for South Wales was taken, as so few were found utilising the definitions of the De Propris work. The findings of the De Propris methodology are interesting even if slightly general. They show the majority of the TTWA's do not have agglomerations of manufacturing, although those that do are dominated by large firms, with only Rhymney and Bridgend showing hub and spoke style agglomerations. This was defined by De Propris (2005) as concentrations of small and large firms connected through a supply chain relationship (gleaned by De Propris by a questionnaire).

The initial goal of this work was to establish the forms of agglomerations present in South Wales today but after applying the De Propris methodology it is impossible to do this using 4 digit data. Therefore a new method is required that does not simply adopt arbitrary measures for cut off points (DTI 1.25) and one that draws attention to areas where concentrations of industry as well as specialisation exists.

5.6. Conclusions and Policy Implications

This research casts new light on the economic geography of South Wales. The region reflects what has been happening on a global scale in most developed countries. Regions which were once the driving force of industrial dominance (Parker (1998), may have begun to fragment and change under the phenomenal power of a new Kondratieff cycle dominated by not physical but intellectual resources Rooney et al (2005). It is therefore the contention that this work is the necessary starting point in any serious empirical investigation into economic clusters. This analysis has looked in detail at the intensity of manufacturing in South Wales, and at the size composition of that manufacturing.

The aim is to give business and policy makers a better understanding of the composition, and hence potentially the workings of, the regional economy. Understanding the geographical distribution of manufacturing is essential to notions of agglomeration and clustering. From a business development perspective these mappings may also help decisions on where to set up operations, as well as point to potential pools of skilled labour or gaps in markets or supply chains. For government and policy makers, these mappings can inform prioritisation and resource allocation decisions, as well as the potential for policy initiatives. The potential benefits can be summarised as:

This research has identified particular areas in South Wales with concentrations of manufacturing and has explored firm size within these concentrations, which may indicate the existence or potential for manufacturing clusters. According to Dunning (1998), the locational choice of enterprises is becoming an important aspect in defining their global competitiveness. However the effects of economic clusters are difficult to measure. Martin and Sunley, (2003), see the social contact between firms as causing spillover effects, so that firms end up clustering to help the flow of information between each other. This interaction can lead to significant productivity growth amongst firms. According to Baldwin and Martin (2003), "agglomeration can be thought of as the territorial counterpart of economic growth." Ciccone (2002) found empirical evidence to suggest that agglomeration has a positive effect in the growth of a regions economy. This supports the idea that clustering may be a successful way of helping to achieve regional growth, implying that policy makers seek to encourage the clustering of firms.

This research provides an insight into the existing industrial structure in South Wales, and offers a context in which incoming firms can be linked with areas most capable of embedding new investment.

Although this research is in the early stages and much work is still to be done, understanding the current picture of the manufacturing sector can help to answer many important economic questions. One of the first insights to be gleaned from this work, is that the traditional view of manufacturing geography of South Wales is no longer appropriate. The other aspect to this research is the process of pinpointing the precise manufacturing sectors present within local areas.

It may be that areas with a long manufacturing tradition, such as Port Talbot, would have many up and down stream linkages, built upon years of operation. Whereas, less traditional areas identified within this research, such as Tenby could offer a very different and unique perspective on the manufacturing sector within South Wales and provide some insight into the future economic direction of the region.

Chapter 5: Results 2: Improving the use of LQ's

5.7. Introduction

The previous section of this chapter sought to investigate the presence of agglomeration in South Wales by utilising the methodology constructed by De Propris (2005). The findings were interesting and painted a new picture of the present economic geography in South Wales. It also allowed the investigation of specific sectors through the use of location quotients, which are thought to be highly agglomerated. This analysis however, posed a problem. Previous studies in the UK utilising this method used two digit SIC data which yielded 8-12 sectors per TTWA considered agglomerated. This study employed four digit SIC data to allow a more detailed analysis of specific sector concentrations often obscured at a more aggregated level. The results seen in the previous chapter show the number of sectors appearing to be highly specialised exceeding 50 in some areas. This was an unexpected problem not foreseen at the commencement of this study, which begs the question with so many sectors being highlighted as specialised which are significant? It may be that with data desegregation the use of the LQ is merely a benchmark rather than an indicator of any great industrial concentration. The other important question to ask, which is fundamental to the progression of this research, is whether the LQ is fit for its analytical purpose when handling this form of data?

After looking at these results it was thought wise to employ the method demonstrated in the work of Beyene and Moineddin to establish confidence intervals for the LQ's. This method has been applied to all the Location Quotients for each of the TTWA's, including those quotients that fell below the traditional value of 1.25.

By employing this technique the LQ now has a threshold value of 1. Table 18 gives a summary of the resulting calculations. For the full results see enclosed data disk. Figure 27 and 28 give a graphical representation of the resulting calculations for the LQ's in the Pontypridd and Newport TTWAs.

Figure 27. Pontypridd LQ Confidence Intervals

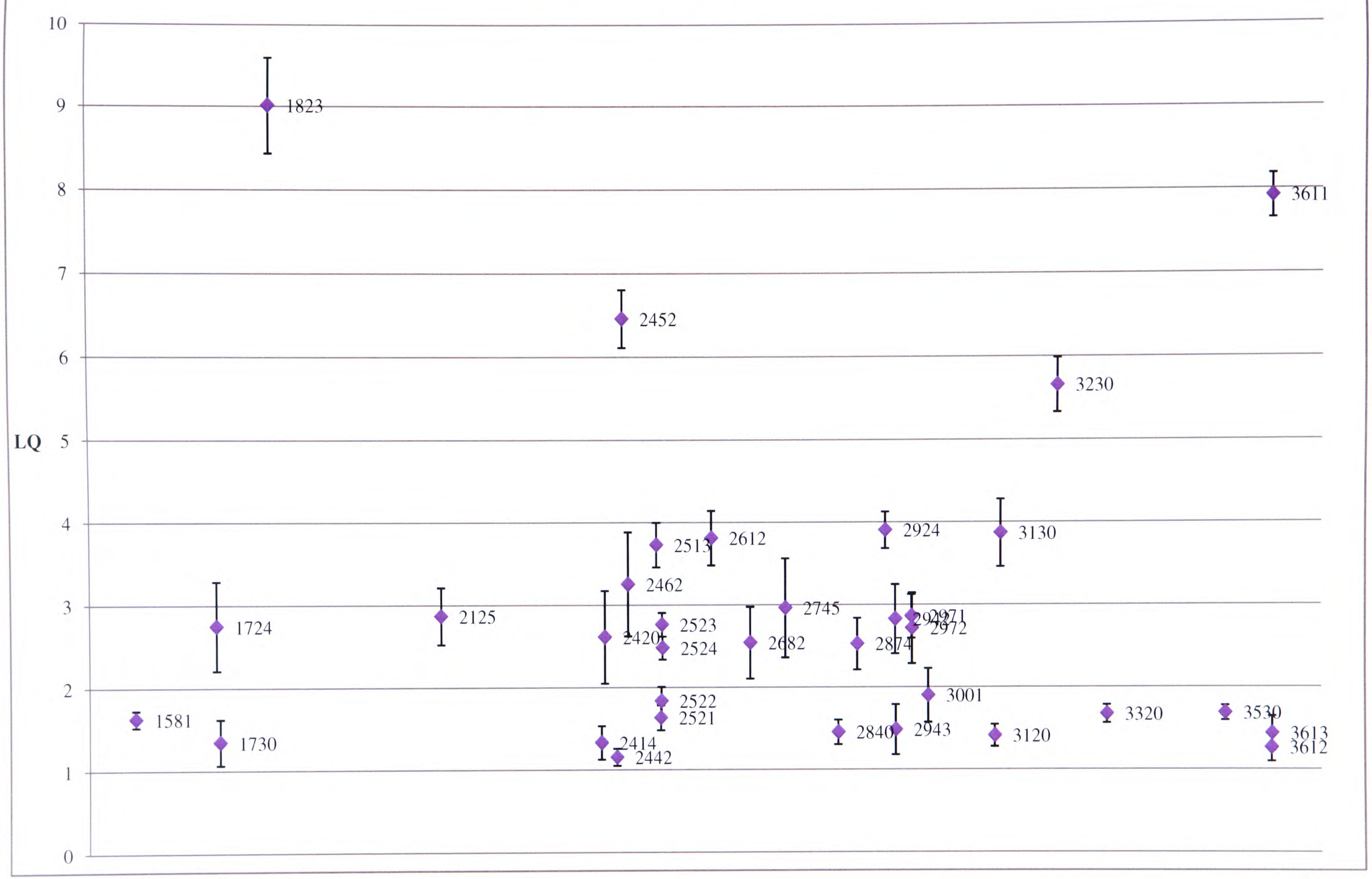


Figure 28. Newport LQ Confidence Intervals

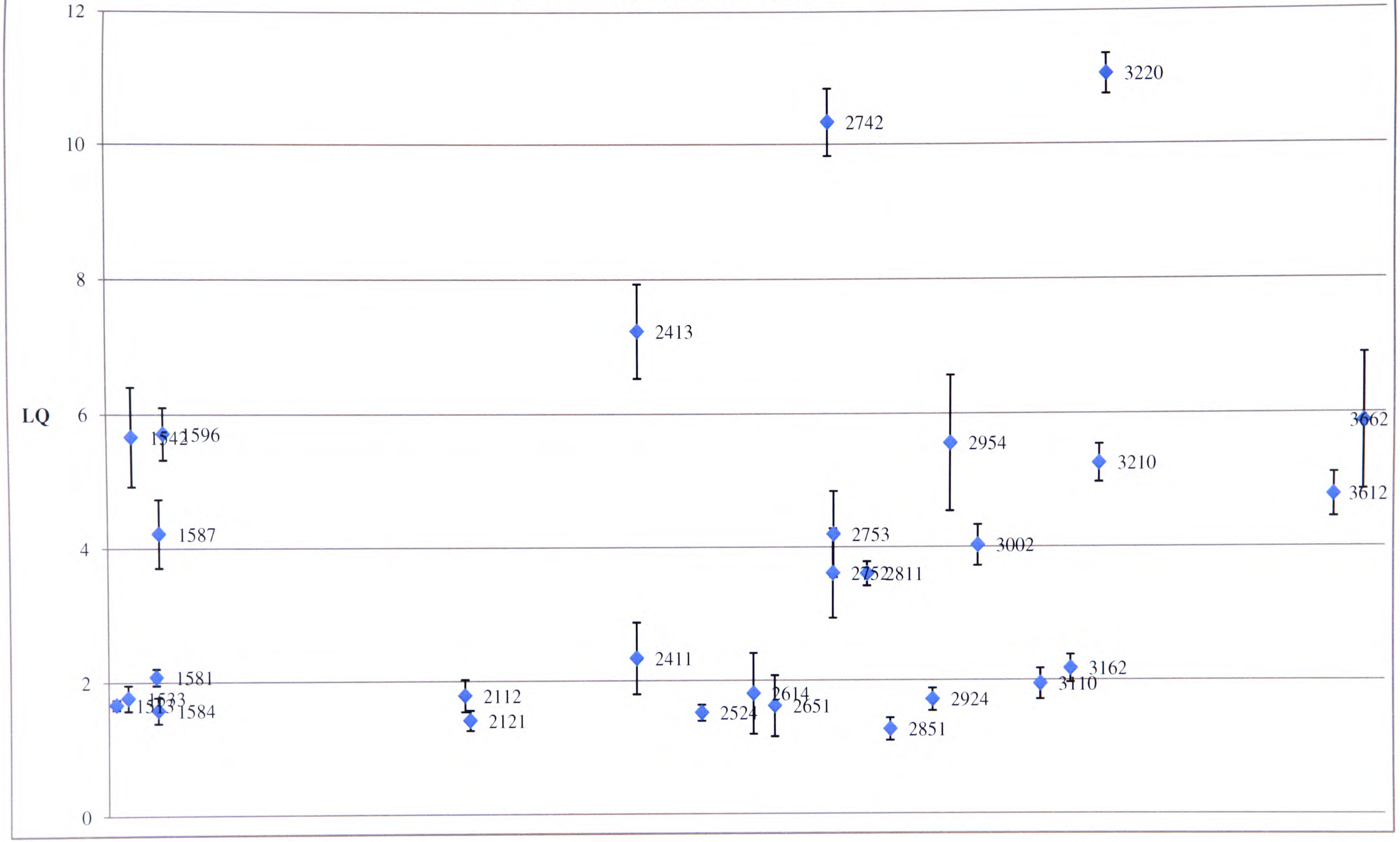


Table 18. Summary of LQ CI

TTWA	LQ>1	LQ SIG>1	Dif
Rhymney	49	30	19
Pontypridd	52	34	18
Lampeter	29	10	19
Llandeilo	26	10	16
Llanelli	29	15	14
Merthyr	22	19	3
Neath	27	16	11
Newport	39	28	11
Cwmbran	32	22	10
Fishguard	16	5	11
Haverfordwest	26	13	13
Cardigan	22	10	12
Cardiff	58	39	19
Brecon	26	15	11
Swansea	40	25	15
Carmarthen	33	19	14
Bridgend	38	27	11
Pembroke	20	8	12
Average	***32.4***	***19.2***	***13.3***
STDEV	***11.5***	***9.6***	***4.0***

5.8. Findings and Policy Implications

In analysing this breakdown of the results there are some stark differences between the numbers of LQ's identified before significance testing and the ones left afterwards, for example, areas such as Cardiff, see an 11 sector reduction in the number of sectors thought to be significant. Overall the study has found on average over 13 of the LQ's calculated using the original methodology are less than significant. The other point to note is that on average a TTWA has 32 sectors with an LQ greater than 1, and when significance testing is employed this falls to around 19. This highlights the substantial difference significance testing has on point estimates.

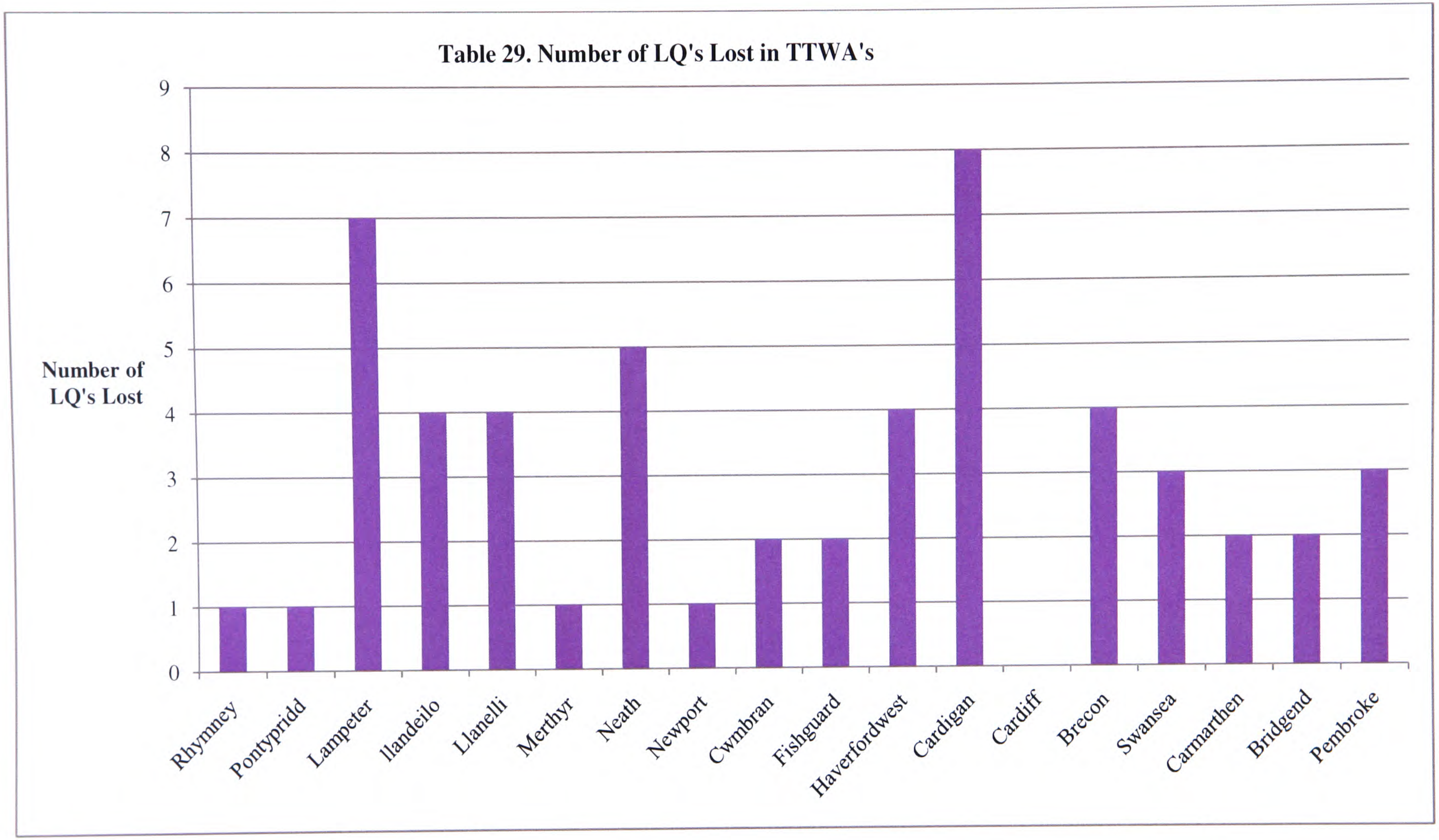
If we take some specific examples, clothing manufacturing SIC (18), considered as being a "cluster" in Wales by the DTI and De Propris. However looking at 4 digit sectors that make up this 2 digit industry, manufacturing is no longer thought to be significant to the TTWA's of Lampeter, Llandeilo and Llanelli. For the same reason, manufacturing of transport equipment SIC (35), again considered as a major sector for Wales by the DTI is no longer found to be significant in the TTWA's of Rhymney, Swansea and Bridgend. These results give some idea of the usefulness of this method for making LQ's a more accurate method of specialisation detection. From a policy perspective this method offers an improved tool for policy makers to analyse specialisations of economic activity. Previous methods such as the LQ are limited to identifying specialisations based upon arbitrary notions of significance, as a result, as seen from the De Propris methodology, numerous sectors are shown to be specialised. The new technique demonstrated here enables a more reliable method of specialisation detection, free from arbitrary assumptions of significance providing policy makers with a more scientific and less bias method of analysis.

The method is by no means perfect and like all statistical frameworks assumption and estimates imply some bias but this has been limited as far as possible. It may be more useful to look at the breakdown of industries lost during this analysis for each TTWA in order to establish an intuitive as well as statistical argument for the exclusion of certain sectors. Table 19 shows the breakdown of two digit SIC's lost after testing for significance in each TTWA, which is graphically represented in figure 29.

Table 19. Lost SIC's in TTWA's

TTWA	LQ Lost at 2 Digit SIC	No. SIC
Rhymney	35	1
Pontypridd	34	1
Lampeter	18,19,20,21,28,29,33	7
Llandeilo	18,22,33,36	4
Llanelli	18,25,32,33	4
Merthyr	26	1
Neath	17,18,20,23,25	5
Newport	29	1
Cwmbran	17,22	2
Fishguard	20,29	2
Haverfordwest	23,31,32,36	4
Cardigan	17,19,20,21,22,33,33,36	8
Cardiff	NONE	0
Brecon	25,29,34,36	4
Swansea	20,21,35	3
Carmarthen	26,32	2
Bridgend	22,35	2
Pembroke	23,26,36	3
Average		***3***

Figure 29. Graphical representation LQ's lost due to lack of significance



In analysing this breakdown of industries lost, the first finding to note is the significant number of SIC's lost in the smaller TTWAs such as Cardigan. This is not entirely unexpected, since theory would suggest regions which have a smaller number of sectors and employees would have a greater degree of variance associated with any calculations utilising their data. In spite of this, the opposite is also shown to occur. Those areas with a large working population, such as Cardiff, yield more accurate estimates with no LQ's at the two digit level being lost in the analysis, whilst sectors SIC 34, 35 and 36 have seen large losses within all the TTWAs across the region. In addition, motor vehicles and furniture manufacturing saw significant losses; whether this is the result of relatively smaller industries compared to large sectors it is impossible to tell without further study.

What has not been considered up until this point, are the relative results yielded from the confidence intervals, to look at spatial autocorrelation and determine whether TTWA'S are the appropriate geographical boundary for analysis. What may be useful at this point is to contrast the relative length of the intervals calculated across different TTWAs. This is because, looking at the length of the intervals, it is possible to examine the relative accuracy of estimates across regions of varying employment sizes. With all statistical methodology like those being used here, the more significant the small size the greater the accuracy of the result, this would therefore imply areas with a large population would have shorter confidence intervals than areas with smaller populations. Table 20 displays the relative confidence values as well as their associated measure for a random sample of sectors.

Table 20. Selected LQ and Confidence Values

1513												
n1	n2	n3	p1	p2	p3	LQ1	LQ2	LQ3	Cfd 1	Cfd 2	Cfd 3	Var
9,181	14,781	15,417	0.048	0.035	0.04	2.22	1.62	1.3639	0.14	0.08	0.075	0.01
1730												
n1	n2	n3	p1	p2	p3	LQ1	LQ2	LQ3	Cfd 1	Cfd 2	Cfd 3	Var
18,275	845	20,290	0.003	0.018	0.194	1.35	6.93	0.1942	0.28	2.92	1.254	1.79
3430												
n1	n2	n3	p1	p2	p3	LQ1	LQ2	LQ3	Cfd 1	Cfd 2	Cfd 3	Var
4,327	9,762	14,781	0.006	0.016	0.386	2.01	6.96	5.0751	0.21	0.23	0.162	0.01

These results partially support the initial hypothesis, that is to say, sample size plays a prominent role in determining the accuracy of the estimations. What is important to note is that some exceptions to this exist. SIC 3430 for example, sees a rise in sample size from 4,327 to 9,762 and yet the confidence measure, by only 0.02. The other notable exception is seen in SIC 1730, a large sample size 20,290 yields a less accurate value than for an area with a smaller sample size. These deviations from theory are not serious and could be as a result of the incidence rates rather than the denominator value in the initial quotient. However, in order to eliminate one possible cause, a spatial autocorrelation test will be run on the samples looking at the confidence value.

Spatial autocorrelation is the correlation of a variable with itself through space, Haining (2005), in this case economic space. Simply put if nearby areas or TTWA's are more alike in terms of economic make-up, then a variable being measured such as concentration of industry may not be occurring randomly. Instead, it may be occurring due to its closeness to other areas nearby, which thereby violates the notion of interdependence thus creating problems when calculating a statistical estimate. If spatial autocorrelation is proven to be negligible in this work, however, then the TTWA may be seen as a useful spatial unit for this form of analysis. Due to the large amount of data in this work it was chosen to simply look at the sample in table 20 as a starting point. The most widely cited measure for autocorrelation analysis is Moran's I (Moran, 1950). It is applied to areas which have continuous variables. It compares the value of the observed variable with the same value in other areas. Moran's I is given by:

$$I = \frac{N \sum_i \sum_j W_{ij} (x_i - \bar{x})(x_j - \bar{x})}{(\sum_i \sum_j W_{ij}) \sum_i (x_i - \bar{x})^2}$$

In the formulation N is the number of cases, Xi is the variable at a particular location, Xj is the variable at another location X is the mean of the variable. The key to Moran's statistic is the spatial weighting matrix Wi,j. This allows the proximity of regions to one another to be identified. The traditional approach is to rank regions next to each other with a one, and regions apart with a zero. The results of the statistic is a coefficient varying between -0.1 and +1.0, the higher the coefficient the greater the intensity of autocorrelation. For this example, table 20 below summarises the results of the autocorrelation test. It must be noted because of the small sample size the weighting matrix took proximity to be the closest, that is, the TTWAs that bordered each other were(1) and any further away (0). The matrix is unidirectional intentionally as this work is not investing causality but simply spatial relations between the locations of industry.

The P value was also calculated for the Moran's statistic (0.0998) implying that the results in table 21 are not significantly different from 1, meaning that spatial autocorrelation is negligible in this data. It must be noted with such a small sample size the limitations are obvious but it is this researcher's belief, the lack of continuity in the industrial composition of TTWA's bordering one another in South Wales seriously prevents spatial autocorrelation problems.

Table 21. Moran's I

SIC 1513	0.215
SIC 1730	0.135
SIC 3430	0.167

Note all significant at 95% level

5.8. Conclusion

This work sought to bring a more rigorous framework to the analysis of LQ data. The method demonstrated has shown its ability to work, that is draw significance of LQ's for highly disaggregated data sets. The fact that the sheer numbers of sectors which after analysis are no longer considered as statistically significant, is a testament to the usefulness of this statistic in improving LQ analysis. It is not however without problems. For example some outliers do exist, and certain values do not enable this form of analysis, such as significantly large LQ's, which do not respond well to the estimation procedure and often yield errors. The very nature of the LQ means these unusual sectors are highlighted as being of significance, and possibly the inability to calculate a variance may be as a product of their dominance in a particular area.

Whatever the reason for this, it must be noted as somewhat of a draw-back to this method. The analysis conducted to determine the statistical nature of the calculated confidences threw up some interesting findings, which may also possibly need to be addressed by further work. The length of different confidence intervals is important as it is the principle that governs the mechanism of significance testing. The good result was the varying degree across regions of different population size as well as LQ values. The slightly odd finding was the lack of continuity in the results with certain large populous areas yielding higher values than slightly smaller areas. Having addressed the spatial autocorrelation problem, this was ruled out of these samples so it could be another statistical problem yet unseen in this form of analysis. However the likelihood of it significantly affecting the outcome of the calculations is not high. To this end this method offers a new tool for the regional economist.

6. Measuring Agglomeration part 1: Sub regional Analysis

6.1 Introduction

The previous chapter dealt with calculating significance for LQ values in order to improve the identification of agglomerations. Up to this point, what was being defined as an agglomeration was based upon the De Propris methodology of chapter 4, which itself is based upon numerous other definitions explored within chapter 2 and 3 of this thesis. The critical appraisal of the so called "cluster" concept/definition in chapter 3 showed the vastly diverging views that exist as to the very nature of agglomeration forces. To what extent these are useful in helping economic growth or innovation among firms is not being questioned here, but the very classification of these notions is. Are clusters or agglomerations simply concentrations of manufacturing? Or is there a more profound nature to these clusters? What this work now proposes to do is to reinterpret agglomeration based upon the initial findings.

The work seeks to underline the importance of industrial concentration from the outset; that is the greater the numbers of a particular industry occupying the same area of economic space, the greater the advantage that accrues to those firms over others not in this space. The nature of the advantage is not being questioned in this work, only that one is thought to exist. Secondly, the new thinking seeks to make a distinction between concentration and agglomeration. Concentration as explored with the use of the LQ allowed an initial mapping of the industrial landscape but to understand in greater depth the forces taking place we must look to theory as well as the empirics.

The location quotient, since its conception with the advent of the economic base model has been utilised by many differing strands of economics, to measure the relative concentration of a particular characteristic within an economic space. Its usage has increased somewhat in the last 15 years with a number of high profile publications such as Porter (1998) adopting the measure to find concentrations, or in his words, clusters of industries.

In recent years and as the cluster brand began to grow in popularity, it has been seized upon by policy makers and academics alike as a way of identifying industrial clusters. Porter's (1990) work has gained popularity amongst government as a new dimension to the development of regional policy, and to a lesser extent was key to the work of Krugman (1996) who emphasised the role of industrial concentration in regional development. Doeringer and Terkla (1995) criticised these models of development as naive and questioned the understanding of policy makers particularly in relation to the precise workings of clusters. This is particularly interesting, in that, clusters began to move from being seen as a spatial phenomenon to being a tool for economic development. Whatever term is used to describe this phenomenon the key characteristic is the agglomeration forces that exist between firms in close proximity. Porter concurs and emphasises Marshall's agglomeration notion. The irony in this is that Marshall conceived this idea in the 1880's and yet today it appears to be giving birth to the spatial component in modern regional economic thinking through the new economic geography school of thought.

6.2. A reinterpretation of Agglomeration

To define a cluster is difficult Martin and Sunley (2003) see it as the effect of social contact between firms causing spill over effects of both a positive and negative nature, meaning firms end up clustering to help the flow of information between each other. The benefits of clusters have been considered in great detail in the literature. Baldwin and Martin (2003) look at the relationship between spatial agglomeration and economic growth and come to the conclusion that the two processes are intertwined. They further note "agglomeration can be thought of as the territorial counterpart of economic growth." Ciccone (2002) carried out research that found empirical evidence to suggest that agglomeration has a positive effect on the growth of a regions economy. This view was also shared by the detailed study undertaken in the US by Barkley et al (2001).

To this end, this research proposes to examine all LQ's calculated as being significant, but in addition examine their interaction with similar sectors in this same industry, thus providing a possible solution to the issue of large numbers of significant sectors. What is being suggested, is that the definition of a cluster is altered to take into account the structure of the region, or in this research the TTWA. Work such as De Propris and Driffield (2006) highlight the importance of the SME's in the structure of current economic agglomeration. This conclusion has also been reached when considering the work of Cooke and Morgan (1998). The work highlighted, in particular, the structure of the economic cluster in Baden-Württemberg in Germany, where large corporations were supplied with intermediary components by SME's in close proximity.

Economic theory would suggest a Coasian reasoning, citing the factor of transactions costs. Whatever the precise significance of their presence there does appear to be strong support for the existence of smaller firms in significant agglomerations of industry.

This research will re-examine the LQ data by measuring the relative employment size within different sectors as well as uniquely piecing together the similarities in SIC codes identified with large LQ values. The LQ approach although adopted in many different ways, has rarely been utilised as a form of spatial pattern analysis. Instead, it has solely been a tool in examining the very simple question, is there or is there not a concentration in a particular area? This work seeks to theorise over the composition of concentrations of employment. In particular, the size in terms of numbers employed within a concentration is an important figure.

For instance, the traditional firm size measure, such as that used in criteria 2 and 4 of the De Propris methodology has one significant flaw: it is based upon national classifications of firm size, rather than at a regional or sub regional level. This exemplifies the arbitrary nature to the notion of firm size, e.g. 1-49 small and 50-199 medium, whereby, different industries may well exhibit only specific firm size traits. What this work proposes, is to decompose the manufacturing employment in a TTWA, sector by sector as well as with relation to size. By examining the industry size in terms of employment and sector specific patterns, it also wishes to establish a typology whereby classifications of concentrations are created, which will enable both the detection and measurement of agglomeration, without putting arbitrary figures on firm size the focus is instead on industry size and composition.

The key to doing this is to make a clear distinction between the notion of concentration and agglomeration. The literature examined so far in some instances refers to the two concepts interchangeably.

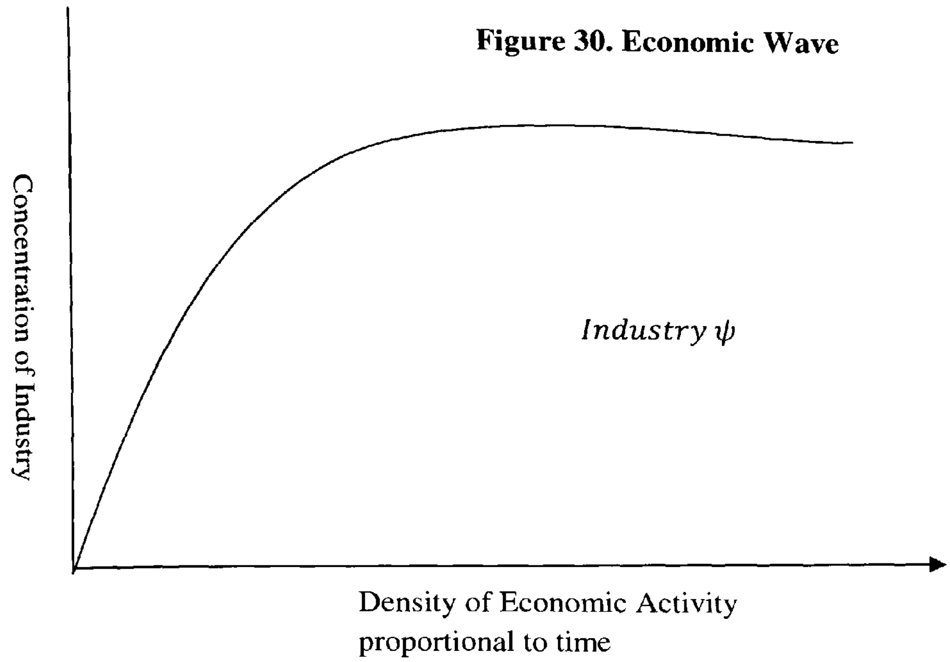
Therefore, when referring to specialised industry in this analysis, there is the intention that there is more than simply a large concentration of a particular sector. There must also be some evidence of a symbiotic relationship between sectors in an industry, or as Marshall (1890) coined it an 'agglomeration' of industry. However, the presence of this is not simple to measure neither is there one unique force at play but a combination of multiple forces.

6.3. Economic and Physical Space

To investigate this notion further it maybe wise to take a more eclectic approach and consider some of the other sciences. Economic space can be thought of as exhibiting similar characteristics to physical space. Authors such as Mirowski (1989) Hall et al (2001) have written about the inclusion of physical science principles into economic analysis. The most high profile call for this though came from Nobel prize winner Wassily Leontief (1982) cited Hall et al (2001) "How long will researchers working in adjoining fields... abstain from expressing serious concern about the splendid isolation in which academic economics now finds itself?" One of the most interesting similarities between economic space and physical space is made by Mirowski (1989), he notes that "[in] neoclassical production theory, the price vector is given by the gradient of the output, in the space of the production factors, just as the vector of a conservative physical force is given by the gradient of potential energy in real space".

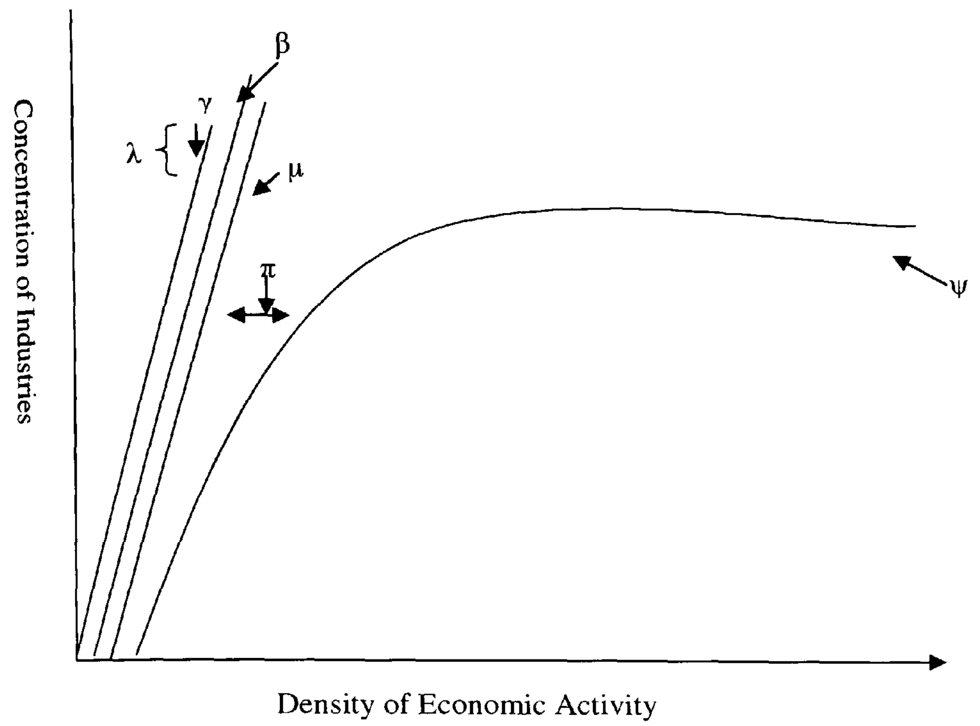
A field that has explored physical space and opened the door to understanding the governing principles to a greater extent than any other is cosmology, by looking at space as an answer to how the universe works. When one reads the work of Hawking and Penrose (1970) there are some major similarities in the work, in particular over the force of gravity and the force of agglomeration. Traditional laws of gravity mean that every object attracts other objects to an extent governed by the mass of the object. This attraction is said to be universal, i.e. no matter what part of space the attraction remains the same Rovelli (2004). However Hawking and Penrose showed that these laws breakdown in parts of space known as a singularity, where gravity turns to infinity, this is everything is drawn in. If we take this idea and think about agglomeration it works much in a similar way. All industries can be thought of as exhibiting agglomeratory forces, which occur in the form of waves that travel across economic space (see figure 30).

What propels this wave is the aim of firms to cost minimise. As an industry begins to grow the land which it sits on increases in value. Other entrants into the industry will spread across economic space in order to get away from these increased rents, thus the concentration of an industry will stop increasing and plateau out.



As in a space time singularity, in clusters these traditional forces breakdown. When more sectors enter they should follow the same path as figure 30, but industries which operate in a singularity the forces of attraction are infinitely greater than that of low cost economic space, thus the result is a build up of industry in one point (figure 31).

Figure 31. Agglomeration and Cluster



This figure shows the presence of a cluster (λ) in economic space which is comprised of industries γ, β, and μ. The agglomeration force between these industries has turned to infinity thus the pull of other locations is no longer powerful enough for firms to wish to leave. The distance (π) is the edge of the cluster where the agglomeration differential returns to normal, thus industry (ψ) continues along its path. This work does not wish to make any claims as regards the fit of cosmological theory to modern economic analysis, it simply highlights the notions that are expressed within this field, which have some stark similarities to the observed economic space that exists today. Hawking and Penrose (1970) established the relationship between singularities and gravity mathematically. This work has not gone that far, however if the presence of these waves is correct, there should be tell tale signs in economic space and thus a model could determine their possible existence.

This is akin to the work of Quah (2002), who sees agglomeration fitting into the traditional neoclassical growth model as a wave that spreads across economic space at points creating greater growth. Within this present work the wave is propagated in the presence of land price differentials. These waves then permeate out across space until they are eventually dispersed. When two waves are in close proximity, (in economic space) to one another, that is to say there are multiple concentrations in a given space, agglomerations occur as the two waves generate forces of attraction between one another. If the forces are strong enough the result is a cluster of industry, if they are not and the pull of the different sectors is too weak the waves continue to travel and spread. The decomposition analysis attempts to measure the static picture of these illusive waves.

Specialised industries which have multiple sectors at different stages of growth (relative size of industry) and operating in the same space could be seen as the result of these waves being attracted to each other.

When reconsidering the notion of agglomeration decomposing employment should be the starting point and in doing so a number of clear assumptions must be made. There is no relationship established between the size of concentrations in terms of LQ values and the number of firms within the sector. This means that the employment levels are taken as the aggregate for the industry; this avoids confusion with the disaggregated 4 digit data which fails to distinguish between sector and firm. This is not a problem within this work as firm size is not being measured, industry size is.

This implies that it is not a firm or a particular number of firms creating the agglomeration but it is the large labour pool composed of multiple sectors of the same industry. This is supported theoretically by the arguments put forward both by Marshall and to a lesser extent by Porter.

Starting to establish a rational for agglomeration, industries which share the same SIC code at the 2 digit level for example 1536 and 1542 are more likely to form linkages with one another than firms in other sectors. Research such as Faustino (2002) justify using this notion with empirical evidence supporting a greater amount of intra industry trade taking place between firms in the same industry compared to different industries which are heavily dispersed[4].

This assumption is not perfect but does imply a strongly homogenous nature to the input requirements of firms within the manufacturing sector in question. This could be supported by the idea of industries requiring specialist intermediary components, such as in the computing or automotive industry. The other assumption is with regard to the agglomeratory forces. The discussion above gave a theoretical perspective to the debate, but to actually measure the force becomes a difficult task. To this end this work connects with an idea proliferated by many regional economists and that is the presence of an industrial anchor.

[4] An ad hoc analysis of the Intra industry trade figures for the manufacturing sectors in Wales shows on average 20% of trade is contributed to same industry purchases in Wales (i.e. excluding imports).

The idea of an anchor began with the work of Markusan et al (1994) who suggested that the presence of large organisation(s) created the base from which other firms may begin to trade. This is because the firms in other sectors in the same industry begin to form relationships usually in the supply of goods and services to the large organisation.

This is similar to the relationships seen in regions such as Baden-Württemberg as noted by Cooke and Morgan (1998). Reports such as Barkley et al (2001) as well as the work of Kuchiki (2007) emphasise the presence of these anchors in manufacturing agglomerations. These works also underline the importance that large numbers of individual workers generating agglomeratory forces. With these assumptions and principles in place, it is now possible to decompose the manufacturing employment sector of a TTWA.

6.4. New Thinking on Agglomeration by Decomposing Industries

The first process is to establish secondary criteria that rates the relative intensity of employment within a specific travel to work area. Calculating a weighted average using the UK aggregate figures as the denominator allows this. The standard arithmetic mean equation (13) is augmented to include a weighting parameter, which is the overall employment level in that industry at a national level. The result is given by equation (14).

$$\bar{\chi}=\frac{\chi_1+\chi_2+\cdots+\chi_n}{n} \quad \text{Or} \quad \bar{\chi}=\frac{1}{n}\sum_{i=1}^{n}\chi i \quad (13)$$

$$\bar{\chi}^* = \frac{\chi_1 w_1 + \chi_2 w_2 + \cdots + \chi_n w_n}{w_1 + w_2 + \cdots + w_n} \quad \text{Or} \quad \bar{\chi}^* = \frac{\sum_{i=1}^{n} \chi i w i}{\sum_{i=1}^{n} w i} \quad (14)$$

These weighted averages are calculated for all those LQ's identified as being statistically significantly > 1 denoted as LQ*.

A TTWA (i) has a manufacturing employment sector given as follows:

$$\eta i \equiv \omega + \tau + \phi$$

η Is the total manufacturing employment within the TTWA this is given by a vector of SIC industries $[SIC_1, \ldots . SIC_n]$. (Mei) is the Manufacturing employment level in industry i.

$$\phi = LQ's \neq LQ^*$$

$$\omega = LQ^* \in [Mei > \bar{\chi}^*]$$

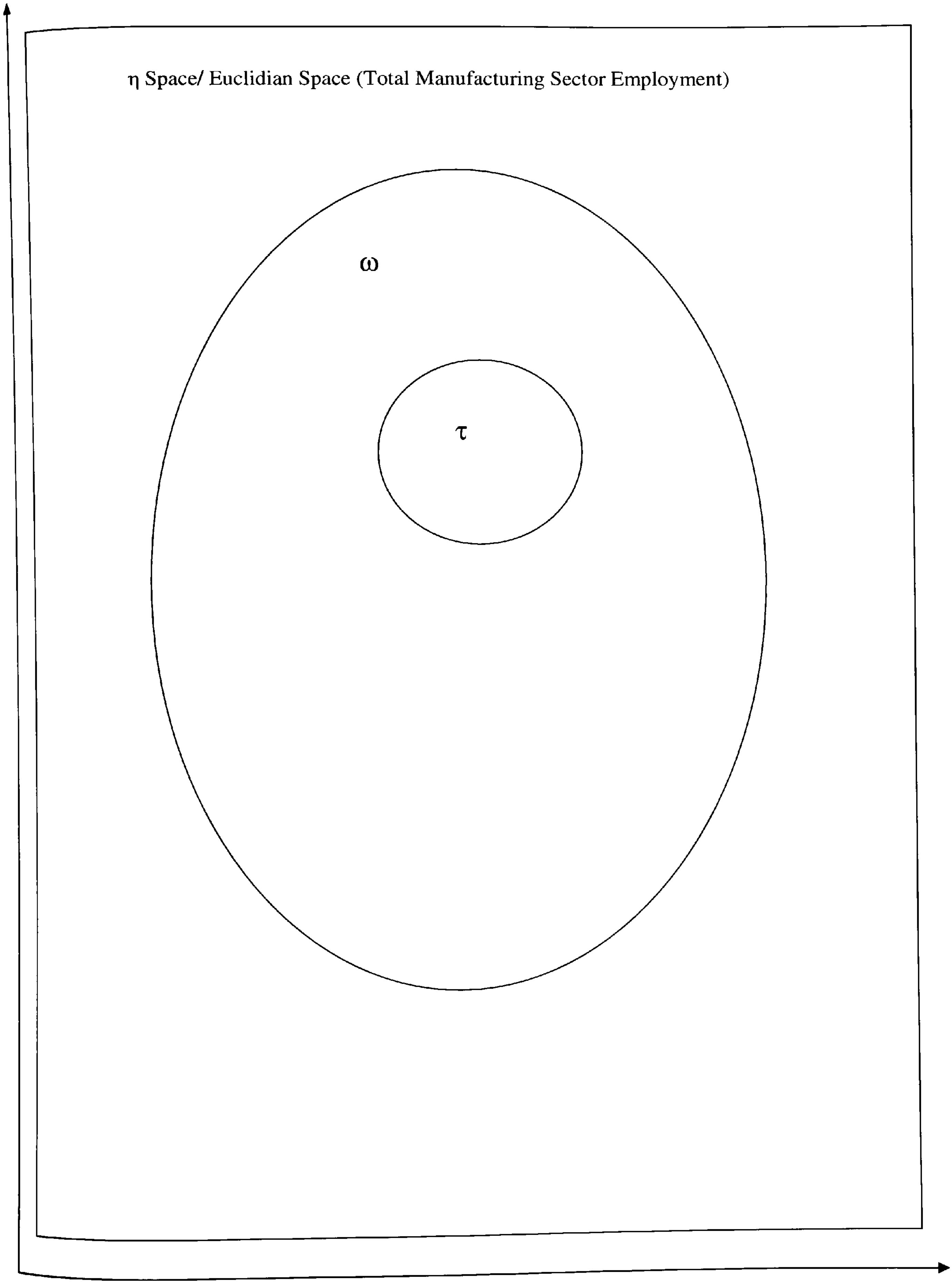
$$\tau = LQ^* \in [Mei < \bar{\chi}^*]$$

Figure 32 shows a graphical representation of the notion being expressed here. For an agglomeration to be significant in an industry it is proposed that the industry must have representations within both the ω and the τ portions of the diagram or

$$Agglomeration = [SIC_{\omega}, SIC_{\tau}]$$

The thinking behind this follows the theoretical notions expressed earlier in this chapter. If agglomeration is like a wave that spreads out across economic space then sectors in the same industrial grouping are the most likely to feel the effects. By considering sectors of multiple sizes, having both less and greater than globally defined averages, the goal is to pick up on all possible agglomeration effects not just 'same firm' growth. Due to the formulation of the LQ one large firm cannot be distinguished from many small firms, however by looking at globally defined averages for a sector, low but still statistically significant employment is measured.

Figure 32. Decomposition of Employment and Agglomeration



That is to say an industry must be composed of more than one significant SIC sector as well as having sectors with less than an average number of employees for that TTWA (weighted against the UK levels). The TTWA must also have sectors with more than an average number of employees. The assumption made with this model is that SIC codes, which share similar 2-digit characteristics, will be the same for industries at the less aggregated 4-digit level. The reason for this choice is twofold. After reviewing large amounts of data for this work as well as examining cluster mapping analysis from around the world one aspect of all these studies that is evident is the loss of information. Studies such as those done in Denmark (Pade, 1991) and the UK (DTI, 2000) regard the loss of firms with few employees as a necessity and only consider 'important' industries, but this fails to take note of the structure of most agglomerations. Agglomerations are composed of firms involved in similar work often up or down the supply stream, this is supported by the argument of having large anchor firms holding the rest in place. By making it a prerequisite for an agglomeration to be composed of more than 1 4 digit SIC grouping it is intended that structural significance of industrial similarities will be maintained.

Table 22. Results After Decomposing Employment

TTWA	LQ*	Mei $>\bar{X}$	Mei$<\bar{X}$	Agglomerations
Rhymney	30	4	26	2
Pontypridd	43	11	32	7
Pembroke	17	4	13	2
Newport	34	6	28	3
Neath	22	3	19	2
Merthyr	19	7	12	3
Llanelli	18	2	16	1
Llandeilo	25	8	17	5
Lampeter	26	5	21	2
Fishguard	16	1	15	0
Haverfordwest	23	5	18	4
Brecon	20	6	14	4
Swansea	25	9	16	5
Bridgend	32	6	26	5
Cardiff	47	5	42	4
Cardigan	21	4	17	2
Carmarthen	32	8	24	5
Cwmbran	27	6	21	4
Total	477	100	377	60
Average	26.5	5.6	20.9	3.3
STDEV	8.6	2.5	7.7	1.7

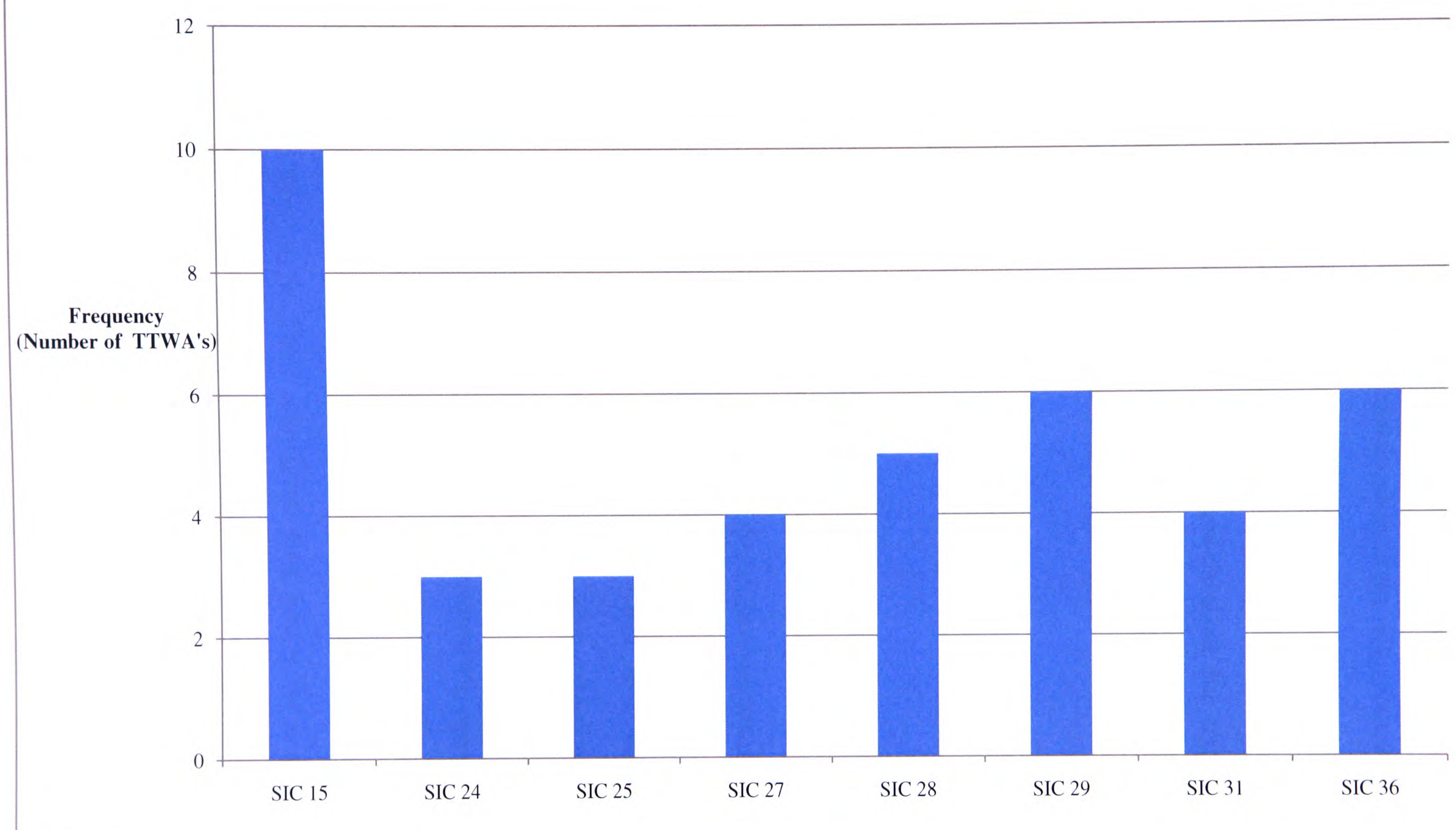
Mei= Manufacturing Employment level in Industry i
$\bar{X}$ = Average Weighted Manufacturing Employment Level

The findings give a very different picture as to the composition of the TTWAs in South Wales. The large number of sectoral LQ's initially found using the standard LQ technique have been ordered and structured according to the details of the model above. With an average of 26.5 a large number of sectors here have a significant presence in each area. This in itself not unusual, however when concentrations are examined a more realistic notion of sector importance is discovered. On average each TTWA has about 6 sectors which belong to a significant concentration base. These sectors could be seen as the backbone of the respective local manufacturing economies. When agglomerations are examined the numbers fall even more dramatically. On average around 3 industries are seen to be agglomerated, with some areas showing none or 1. These agglomerations identified offer the ideal starting point to investigate the spatial distribution of manufacturing in the region. Their very makeup indicates the highly significant nature of the sectors involved as well as the geographical similarities in their existence. Table 23 gives a breakdown of the individual agglomerations identified; Figure 33 displays the agglomerations with the highest frequencies in South Wales.

Table 23. Agglomeration SIC's by TTWA

TTWA	Agglomeration 2 Digit SIC
Rhymney	24, 31
Pontypridd	15, 24, 25, 29, 31, 31, 36
Pembroke	22, 28
Newport	15, 27, 28,35
Neath	27, 28
Merthyr	28, 29, 36
Llanelli	27,35
Llandeilo	15, 22, 26, 29, 36
Lampeter	15, 22
Fishguard	NONE
Haverfordwest	15, 20, 29, 35
Brecon	15, 18, 20, 22, 28
Swansea	15, 25, 27, 28, 31,35
Bridgend	25, 26, 32, 34, 35
Cardiff	15, 24, 32, 35
Cardigan	15, 26
Carmarthen	15, 20, 25, 29, 36
Cwmbran	15, 29, 31, 36

Figure 33. Frequency of 2 Digit SIC Agglomerations in South Wales



When examining the number of industries with agglomerations across South Wales it is remarkable the number of similarities that exist between some of the areas. This table shows how SIC 15 (Manufacturing of food and beverages) is highly agglomerated within the region with representations in almost every area. Similarly SIC 28 (Manufacture of fabricated metal) and 36 (Manufacture of furniture) are present in large numbers across the region. These agglomerations do not offer insight into the success of these specific sectors but they do highlight the potential economic conditions that exist across the region.

6.5. Conclusions and Policy Implications

The results outlined in this chapter have yielded some very interesting results both from an academic as well as a policy point of view. The basis of the new thinking was not purely economic theory; it was also informed through insight but the intuitive element that comes into agglomeration. The key to this analysis, and thus its results relies on the use of applied data, which offers some insight into the industrial make up of an area. When using highly disaggregated data as was done in this project the need to create clarity in the data set is self evident. Previous work which has opted to remove so called "non- compliant" industries seems to this researcher to be a poor method of analysis. The decomposition approach (DA) allows a more detailed position of analysis to be adopted rather than trying to make gross generalisations about individual sectors. Like most economic pieces of work assumption is the important dynamic in the analysis. These assumptions have tried to be as realistic as possible to avoid the heavily theorised approaches used in other studies of this type. However the limitations, notably the lack of interaction between individual sectors creates a problem as regards the precise nature of the agglomeratory forces.

The proposition of agglomeratory waves is not a new notion but their travel through economic space as outlined in this chapter is. To prove the existence of these agglomeratory forces is a significant challenge. This work has attempted to justify the subtle tell tale signs that these waves leave behind along their journey, whether it is possible to take this notion further remains to be seen. However the goal of this study is to offer new insight into agglomeration based upon existing LQ data.

The results for South Wales are very positive and offer real potential for further economic study, in particular focusing on the identified agglomerations as a starting point from which individual sector studies may be carried out. The DA analysis proposed in this chapter enables the identification of sub regional agglomeration. Policy makers can utilise this form of analysis to better inform decision making on sub regional economic policy. By looking at specific areas, industries over looked at the national level, but of regional importance maybe identified. This is useful in making sense of the numerous specialisations identified when using highly disaggregated data. What this work now wishes to do is to investigate agglomeration at a regional or national level. The focus will now turn to looking at agglomeration in Wales.

6. Measuring Agglomeration part 2: Regional Analysis

6.6. Introduction

This section of this chapter will apply the C statistic, constructed in chapter in 4, to the case study region. To this point the case study region used has been South Wales, for the purposes of the C statistic, the whole of Wales will be used to establish the levels of industrial agglomeration.

6.7. Context and History of Manufacturing in Wales

The Welsh economy was one of the first to industrialise. Fuelled by rich deposits of coal and iron ore, the economy quickly grew to become one of Europe's major manufacturing regions, a position maintained till the early 1960's. This suddenly changed rapidly during the 1970's, with the relative decline of the UK's industrial base, particularly hard-hitting in regions reliant on traditional heavy industries such as Wales. The mid 1980's to early 1990's saw further change, with an influx of manufacturing investment in new lighter industries and the continuing rise of business and public services, followed by further declines in manufacturing's share of Welsh jobs through the turn of the Millennium.

Today the Welsh economy is a very different place, with the manufacturing sector providing jobs to around one in seven of all employees in Wales. There is an important research need to now describe and understand the nature and spread of this very different manufacturing map of Wales. The decline in manufacturing as a share of employment in Wales is illustrated in figure 15, whilst Table 6 compares manufacturing shares across British nations in 2004.

Figure 34. Percentage of Welsh Workforce in Manufacturing 1980-2004

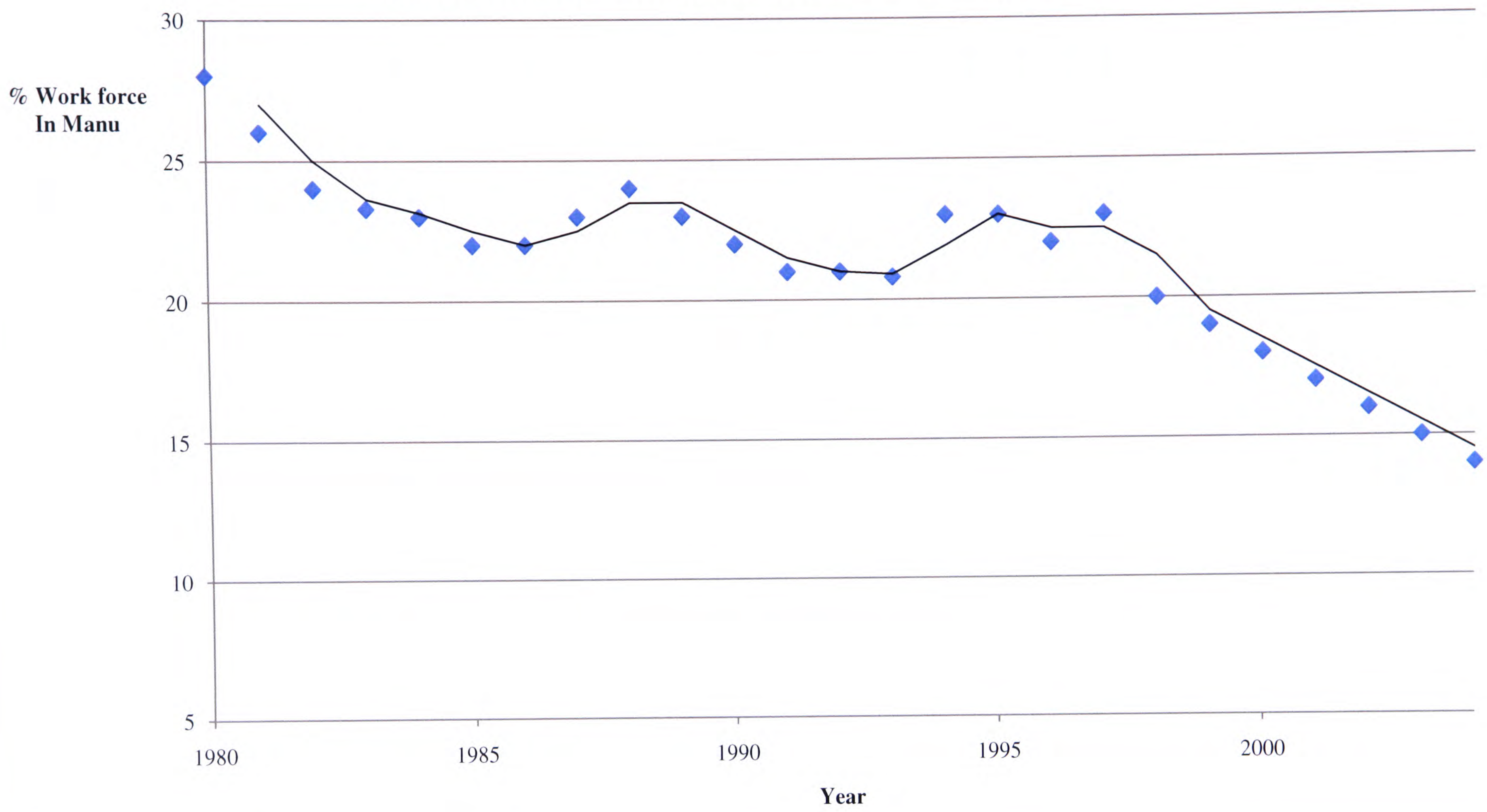


Table 24. Manufacturing employment in Britain 2005

Area	Number Employed In Manufacturing (000's)	Manufacturing as % of Workforce
Scotland	229.7	9%
Wales	168.7	14%
England	2545.9	11%
Great Britain	2944.3	11%

For the UK as a whole, the manufacturing industry represents a sixth of national output and employs over 3 million people[5]. In contrast, two-thirds of the UK's GDP is now accounted for by the service sector and this share is growing. Despite its declining employment share, manufacturing remains important to the UK economy. One reason is the impact on international trade, whereby manufacturing makes up around 60% of UK exports (based upon figures for 2004), which in turn affects exchange rates. The state of the sector at national and regional level thus requires careful monitoring.

With an eye on economic stability, a major aim of both central government and the devolved authorities in the UK is to maintain, if not to grow, manufacturing outputs and employment. The Welsh economy compares unfavourably with the rest of the UK in terms of Gross Value Added (GVA) per capita.

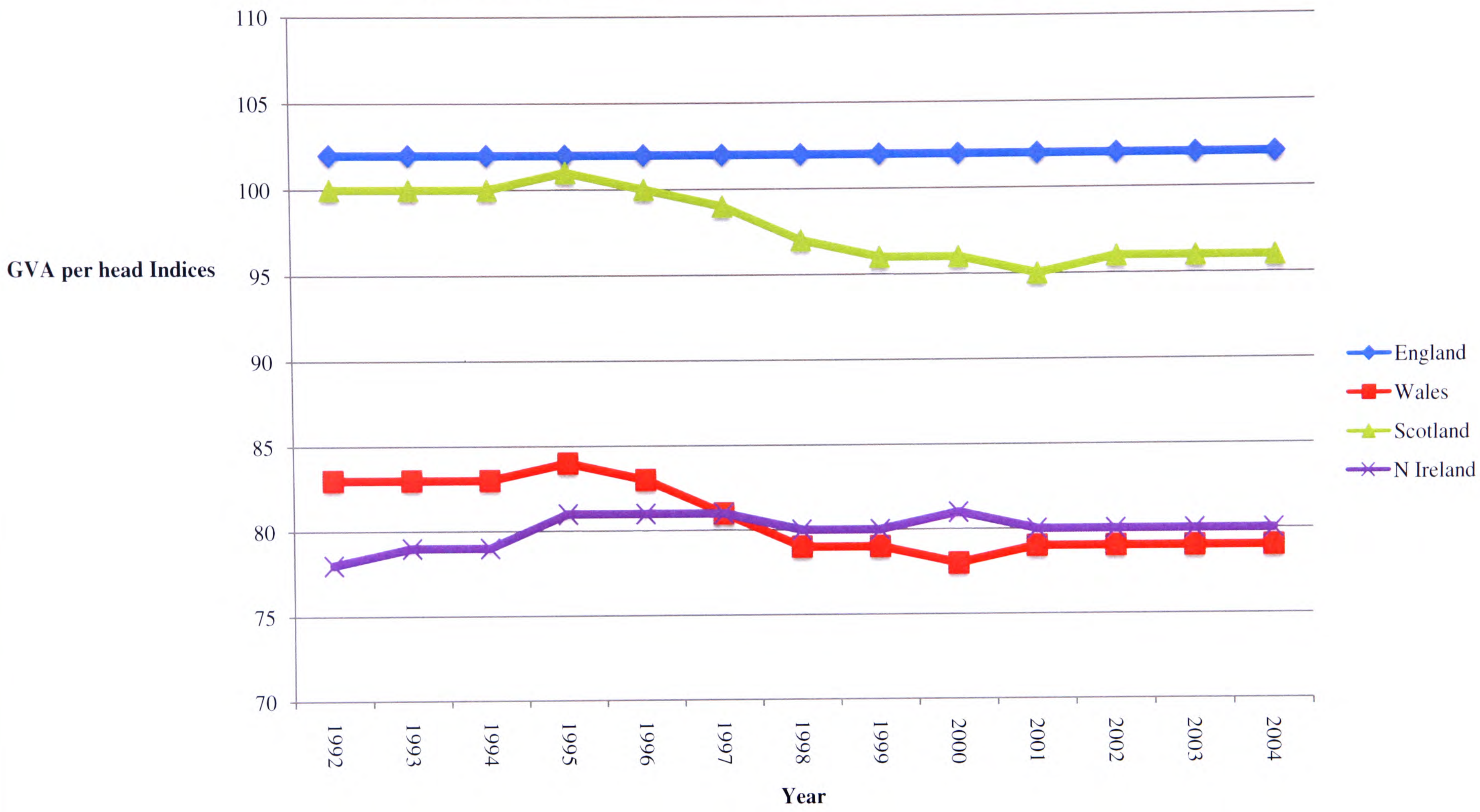
5 Figures found from DTI Strategy review 2005.

In relative terms, Wales is now bottom of the UK national GVA/capita league, having recently been overtaken by Northern Ireland. (See figure 35)

Contemporary Wales is inherently diverse in terms of manufacturing, brought about by shifts in the economic conditions of the later 20^{th} century. During the 1980's and early 1990's, Wales attracted substantial manufacturing Foreign Direct Investment (FDI), particularly in the electronics and automotive engineering sectors (Hill and Munday, 1994). Wales is now an important producer of parts and sub-assemblies for automotive corporations. The most important operators include Ford, with an engine plant at Bridgend, and Bosch with an alternator factory nearby. The Irish corporation, the Quinn Group joined this of companies in 2005 by opening what is planned to be the largest radiator manufacturing plant in the world in Wales. In recent years, production of high technology outputs in Wales has increased with greater production of consumer electronics, telecommunications equipment, and more recent expansions from the optoelectronic industry, through the world leading firm Agilent Technologies based in Wales[6]. At present over 130 North American and 35 Japanese companies have operations in Wales[7].

[6] Information obtained from the Welsh Optoelectronics forum.
[7] Figures adapted from Eurostat Website.

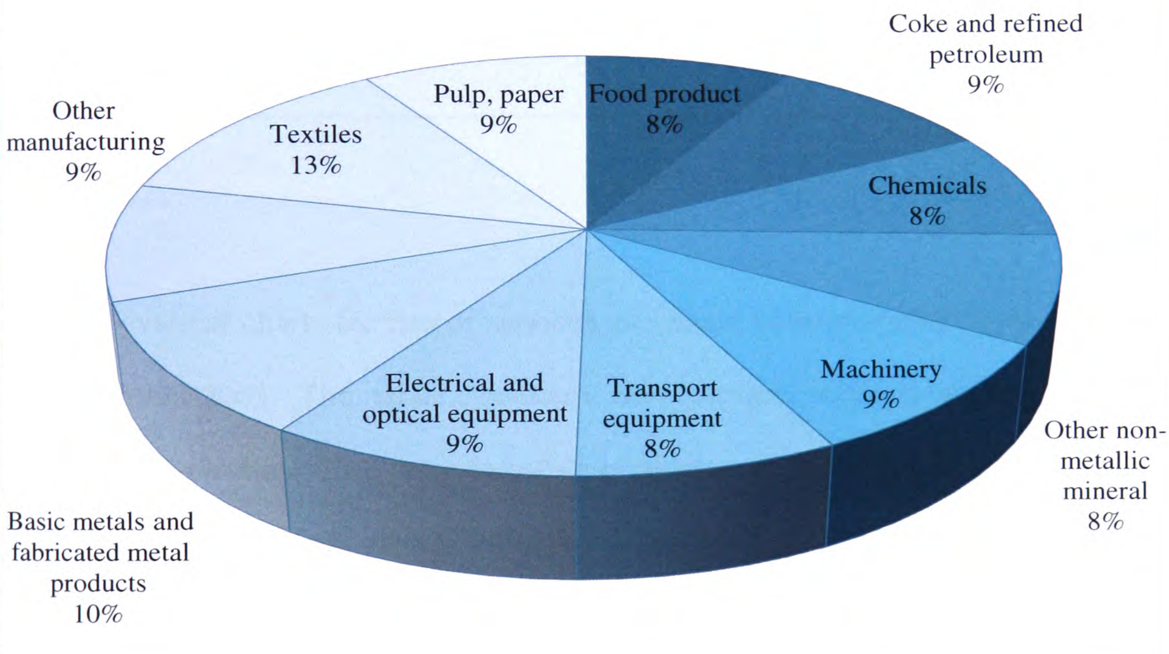
Figure 35. Regional Breakdown of Gross Value Added per Capita



6.8. Welsh Manufacturing Data

Figure 36 and 37 shows sector employment shares for the manufacturing industries in Wales for 1998 and 2004, respectively, which show Wales has a very diverse manufacturing base. Total employment in Wales has also been rising, with 120,000 more people in work since 1999[8], largely because of job growth in private and public services.

Figure 36. Welsh Manufacturing Sectors 1998



[8] Data obtained from Nomis and CBI reports.

Figure 37. Welsh Manufacturing Sectors 2004

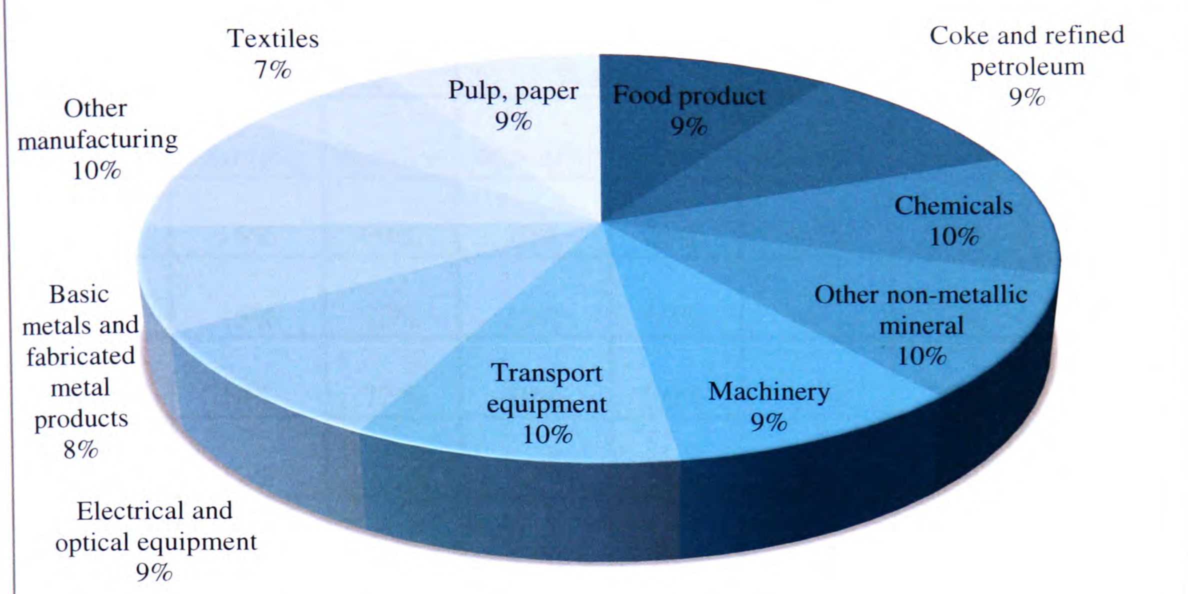


Table 26 overleaf charts the rise of services as a share of employment across the UK nations between 1998-2004. The table illustrates how services have a slightly lower share of employment in Wales, since manufacturing represents a large share of the economy. Sectoral shifts have coincided with growth in terms of jobs but have also created many challenges for policy makers struggling to understand the complexities of changing economies.

Table 26. Percentage Shares by Region in Services and Manufacturing

Region	Scotland		Wales		England		GB	
Sector	*Manufrg*	*Service*	*Manufrg*	*Service*	*Manufrg*	*Service*	*Manufrg*	*Service*
1998	15%	69%	20%	69%	17%	71%	17%	71%
1999	15%	70%	19%	69%	16%	72%	16%	72%
2000	14%	72%	19%	70%	15%	73%	15%	73%
2001	12%	73%	17%	71%	14%	74%	14%	73%
2002	12%	74%	17%	72%	13%	75%	13%	74%
2003	11%	76%	16%	73%	13%	76%	13%	75%
2004	10%	76%	15%	74%	12%	76%	12%	76%

*** Source adapted from Nomis 2004 Figures**

6.9. Spatial Measurement in Wales

The work will now compare and contrast the new C statistic with an existing measure of agglomeration surveyed in chapter 4, the EG index. Each of these methods provides a different rational for the existence of an agglomeration of industry and it would be interesting to question whether there are any similarities.

The configuration of economic space is an amalgamation of emerging forces, traditional supply and demand along with the ever-strengthening presence of globalization.

Agglomeration as a driving force for economic growth has been discussed in depth through this study, but an attempt to measure the force through an analytical index has not been developed to this point. It is the goal of this chapter to understand agglomeration through this new C index that allowing the presence of agglomeration forces to be determined across different spatial levels but at the same time remaining consistent within its estimation of direct effects.

6.10. The Use of the C Statistic in Wales

Wales has since 1995 produced regional input output tables through the Welsh Economy Research Unit based at Cardiff University. In Wales these tables have been derived from National UK data but have steadily incorporated surveys collected from Welsh businesses.

Each new edition gives more data: thus the latest edition published in 2000 has brought about a fuller picture of the input output linkages in Wales. In order to establish the level of interaction amongst industries within the same sector the domestic use matrix can be utilised. The matrix provides figures on expenditure between firms in different sectors (inter) and between firms in the same sector (intra). This existing information is however restricted to 2 digit SIC data for the whole of Wales.

Due to the lack of readily available data and the time consuming nature of the job, these tables have not been up dated for Wales since 2000, whereas UK national tables were reproduced in 2004/2005.

The differences between the values for intra trade in 2000 between the UK and the Welsh input output tables are marginal, with little if any major differences between sectors. To this end, and to avoid temporal errors UK intra trade figures could be seen as a good estimate as to what the intra trade figures are likely to be in Wales.

For this study the C statistic was calculated for 19 SIC manufacturing sectors across Wales. Although the study to this point had focused on South Wales, it was considered due to the lack of sub regional input output tables that any new agglomeration measure using all Wales tables should derive all Wales industrial agglomeration values. The change from simply looking at South Wales is necessary as the goal of this measure is to capture the specialisations of industry rather than simply sectors. It is the intention that this measure maybe used in any country, or equally large spatial domain, to establish the level of agglomeration for any given industry. As well as calculating this new statistic it was considered wise to employ some form of existing statistic as a benchmark, which although constructed differently is trying to examine similar factors as a proxy for agglomeration. The EG statistic was decided upon due to the high degree of popularity among scholars as well as its ease of calculation. The EG was calculated in the same way derived in this chapter, including utilising the schmalensee proxy to calculate the Herfindahl index, since believing that the data restrictions in the US are mirrored in the UK.

6.11. Results of the EG and C Statistic

Table 27 reports the both the Herfindahl measures, as well as the G and the Ellison and Glaeser EG (γ). The final column of the table shows the results of the C statistic.

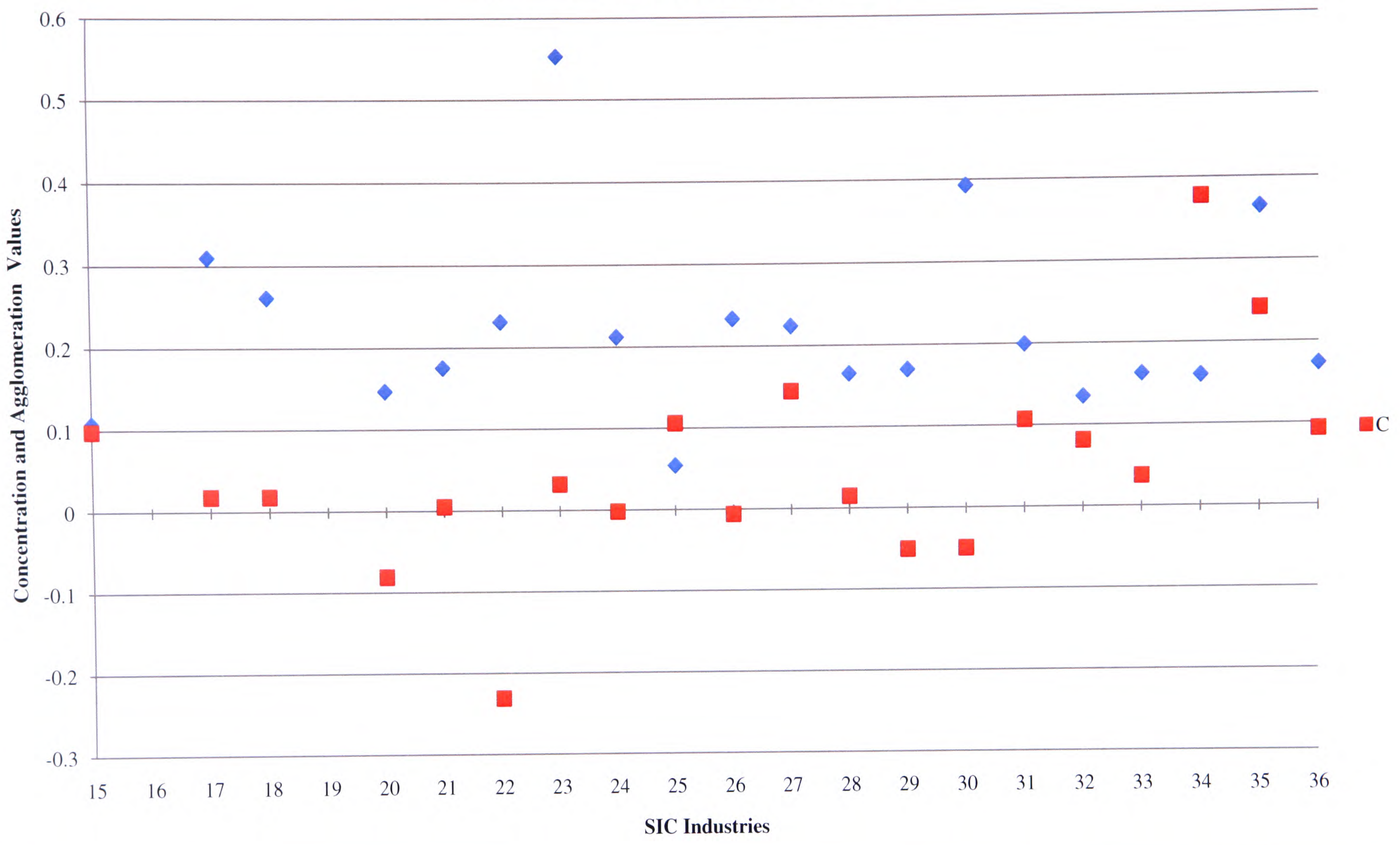
Table 27. EG and C Statistic Comparison for Wales (2005) Data

SIC	H	G	EG(γ)	C
15	0.09	0.1644	0.1077	0.098*
17	0.002	0.2721	0.3098	0.018
18	0.008	0.2335	0.2612	0.018
20	0.001	0.1295	0.1468	-0.081
21	0.009	0.1598	0.1754	0.005
22	0.001	0.2026	0.2311	-0.231
23	0.097	0.5208	0.5523	0.032
24	0.003	0.1871	0.2119	-0.002
25	0.091	0.1227	0.0543	0.106*
26	0.003	0.2058	0.2331	-0.006
27	0.011	0.1958	0.2238	0.144*
28	0.004	0.1474	0.1652	0.015
29	0.001	0.1491	0.1697	-0.051
30	0.01	0.3486	0.3926	-0.050
31	0.002	0.1757	0.1993	0.107*
32	0.007	0.1231	0.1348	0.081*
33	0.003	0.1439	0.1622	0.037
34	0.005	0.1435	0.1599	0.377*
35	0.023	0.3347	0.3644	0.241*
36	0.001	0.1518	0.173	0.093*

*Indicate Greater than Welsh average

The results of the Ellison and as well as the C statistic are scattered plotted in figure 38. The most notable finding looking at the results is the large contrast between the two statistics. This is an important outcome because it illustrates that, concentration measured via the EG (γ) statistic is not the same as agglomeration measured by the C Statistic. To derive meaning from the findings it is important to take a closer look at figures, which show the starkest differences.

Figure 38. Scater Plot of γ and C Statistics



Upon initial observation there appears to be some similarity between the two statistics proportionally speaking see table 28 for the associated statistics. SIC 15 (Manufacturing of food and beverages) and 20 (Manufacture of wood and products of wood and cork, except furniture) show a very similar trend, however there is a stark difference between SIC 34 (Manufacture of motor vehicles). The C statistic records the highest agglomeratory force whereas the Ellison and Gleaser measure shows a below average figure of just 0.1599 (Average for Wales 0.22). To ascertain why this may be interesting to look at some of the characteristics of this sector. Over 90% of the industry is specialised, that is having an LQ greater than 1 and almost 46% of the sales taking place is intra industry trade. These factors point to nothing conclusive but it is evident to see why the C statistic identified a high agglomeration industry. There could be one underlying reason for the divergence of the two measures and that is the spatial scales.

The C statistic constructed here allows for the first time a measure of agglomeration consistent in estimation unified under a single definition, this is a concentration of specialised industries with intra industry trade present. The statistic improves on the existing solely concentration based measures such as the EG utilised in most cluster studies by examining both interaction and specialisation of industry.

The C method is constructed initially from LQ's calculated using a UK denominator. The EG statistic as noted by Feser (2000) is very sensitive to changes in aggregation of data, for the purposes of this calculation 2 digit data was used which produced exceptionally high values compared to the original 4 digit data used in their 1997 study. These values do however agree with a two digit data analysis conducted by Braunerhjelm and Borgman (2004).

Table 28. Summary Stats

	EG (γ)	C
Average	0.2266	0.0501
StDev	0.1100	0.1238
Min	SIC 25 (0.054)	SIC22 (-0.231)
Max	SIC 23 (0.552)	SIC 34 (0.377)

6.12. Policy Implications

The C statistic gives for the first time policy makers the ability to quantify the levels of agglomeration within industries. Agglomeration, being interaction and specialisation, this definition clearly encompassing the forces of major interest to governments. What has not been contrasted to this point are the results between the sub regional and regional findings. These two methods (Decomposition Analysis (DA) & C analysis) provide different rational for the existence of agglomeration but maybe seen as two sides of the same coin. If a government identifies agglomerations of industry across the sub regions of a nation, then it is important to then identify the national significance of these findings. The DA technique maybe seen as a policy filter, or a first step in identifying the industries of importance to a nation. The C static may then be applied to the industries indentified in the DA analysis so as to quantify their national importance. Table 29 compares the industries found with the DA analysis and their relative C value.

Table 29. DA and C Statistic Analysis

DA Analysis SIC Highest Frequency	C statistic
15 (Manufacturing Food and Beverages)	**0.098***
24 (Manufacturing Chemical Production)	-0.002
25 (Manufacturing Rubber and Plastic)	**0.106***
27 (Manufacturing Basic Metals)	**0.144***
28 (Manufacturing Fabricated Metal)	0.015
29 (Machinery and Equipment)	-0.051
31 (Manufacture Electrical Machinery)	**0.107***
35 (Manufacture Transport Equipment)	**0.241***

* Signifies greater than Welsh average

When one examines the findings from table 29 the first thing to note is the further removal of industries from what is said to be national significant, going from 8 to 5. The industries SIC 15,25,27,31,35, have now passed through statistical significance testing, employment decomposition analysis as well as agglomeration analysis. With a degree of certainty one may now conclude that these industries exhibit the greatest agglomeration within the Welsh economy. This is of interest because this technique shows up sectors already thought by some to be in clusters, as well as not supporting the inclusion of other sectors for example SIC 25, 27, 31, and 35 are also identified in the DTI (2000) cluster report as well as Henry et al (1996) and the world cluster report from Harvard University, Porter (2002). This technique has however also identified sectors SIC 15 not considered by these reports as being clusters. However literature from Sparkes et al (2001) on SIC 15, note the strong performance of this sector in the Welsh economy. The tools constructed in this study (DA and C) therefore allow known clustered sectors to be identified through a more detailed robust statistically accurate approach, as well as identifying other possible sectors which also share the characteristics of agglomerations.

From a policy point of view the technique introduced in this work for the first time give a complete set of statistical techniques to enhance the knowledge of a nations industrial clusters based upon a unified methodology not affected by semantics. Any of the tools on their own be they the LQ* the DA analysis or the C statistic are useful for ad hoc analysis but when combined give the policy maker a way of empirically identifying industries of significance to a nation. Table 7 introduced in chapter 4 has now been modified to include a link between the DA and the C analysis.

Table 30. Definitions and Classifications of Agglomeration

Phase	Characteristic (Structure & Space)	Classification	Level of Aggregation for Identification	Statistic for Identification
1	Industries in the same location	Concentration	2 Digit	EG
2	Specialised Sectors	Specialisation	4 Digit	K or L or Gi
3	Concentrations of specialised sectors of an industry	Specialised Concentration	2&4 Digit	LQ or Amended EG
4	Industries specialised based upon composition of sectors	Agglomeration(Sub Regional)	2&4 Digit	DA
5	Specialisation of Industries, as well as interaction between these sectors	Agglomeration(Regional)	2 Digit	C
6	Combination of Phases 4 and 5.	Significant National Agglomerations	2&4 Digit	C+

The C+ technique simply involves combining the methods of the DA and the C statistic together. This chapter has introduced these two forms of agglomeration analysis (sub regional and regional), when combined together they provide a powerful tool for constructing regional and national economic policy.

6.13. Conclusions

Concentration and specialisation of industry has dominated the regional economic literature over the last decade and their popularity appears to be increasing both from an academic as well as political point of view. The initial measures looked at in previous chapters of this thesis have had two distinct features, the first being there mathematical reasoning the second being there data requirements. The mathematical rational for the use of distribution based measures is easy to be seen. The choice of distribution when analysing any variable is key to the output if we presume along the lines of the EG statistic, a normal distribution certain assumptions are being made regarding how industry is spatially segregated. Whether this is the correct approach however is open to criticism. Other measures have moved away from comparing the distribution of a sector to a normal distribution due to the problems of assuming such an idealist relationship. Within which ever measure is being used the key determinate of its output is the chosen scale of the data.

When using disaggregated employment data the denominator is without doubt the most important component in the calculation. If there is a concentration in a particular industry when using Welsh aggregate data as the denominator, if this is not the same and perhaps disappears using a greater scale such as the UK as a denominator does this mean it is less relevant?

Agglomeration as a force should create benefits to those firms that are involved. To this extent is the spatial scale the underlying factor in determining if these benefits actually exist? The idea of creating an agglomeration rather than a concentration or specialisation index was with this in mind.

Chapter 3 examined the notion of "clusters", as a policy concept anchored on the notion of concentrations of industry, this implied the notion of spatial scale being at the heart of the debate. Whether it is truly possible to find clusters in the sense they were considered by some is open to question. The term cluster, as it is described through chapter 3 appears to be more of a noun rather than a verb. Agglomeration as a force (verb) on the other hand appears to be a concept with a lot of weight; intra trade as well as specialisation are the conditions that give rise to the force. The precise nature of agglomeration is not being questioned here but the measurement of its presence is. If these two components are considered to be the cornerstones in explaining this force then it is with them we must look to quantify it. The measurement outlined in this work has one significant drawback and that is the need for specific regional input output tables. In the UK table now exist for Scotland, England and Wales. In other parts of Europe the extent to which tables are developed is on a much more aggregated scale as such the measure may need to be adapted. From this research it is clear that aggregated regional economic data is useful, but to give a better understanding disaggregation must be incorporated into regional economic analysis.

Chapter 7: Conclusions

"Not everything that counts can be counted, and not everything that can be counted counts," Albert Einstein

7.1. Why was the Work Done?

This research set out to investigate agglomeration/clustering in South Wales in an attempt to give a better understanding of this elusive concept. One of the most complex tasks in this work was to establish what agglomeration actually is. Most of the literature surveyed in chapter 3 shows a field confused and complicated by diverging opinions, mixed data and numerous definitions. This insight says a great deal about the task which lay ahead in this work, it also gives the first goal of this work and that is to extrapolate some form of definition applicable for the successful identification of manufacturing agglomerations. To do this an extensive review of the historical routes of the subject was traced, to ascertain the basis of where the notion of agglomeration came from. This work seeks to move away from the micro Porterian view of the cluster and move the debate to a more macro driven perspective. This work wishes to note there is a difference between an economic cluster, that is a significant concentration of industry and an agglomeration, a significant concentration of industry with some form of intra trade relationship there by creating a circular causality. To this end this work does not seek to investigate competitiveness or nor for that matter debate the ability of economic clusters to generate economic growth. This work instead wishes to theorise and in doing so create a new analytical approach to the study of agglomeration. Specialisation rather than simply concentration is at the heart of the matter, measures such as the location quotient do not set about to understand concentration and never did.

Their inclusion in studies as a measure of concentration is inaccurate, and paints a false picture of the distribution of industry rather than specialisation. The tools and models introduced in this thesis aim to reequip the regional economist giving them a better understanding of agglomeration and its effect on the economy in general.

7.2. The Original Goals of this Research

- Attempted to survey the existing methods within spatial economic analysis focusing on the spatial distribution of economic activity.
- It intended to utilise existing methodological approaches such as the location quotient to map the presence of spatial agglomeration in South Wales.
- The second phase of the analysis was to introduce the notion of agglomeration economies into the research. Although not a new concept a great deal of regional economic literature has latched onto the concept in the last ten years.
- The research has attempted to ascertain the presence of agglomeration and agglomeratory forces in South Wales through both existing as well as new spatial economic techniques.

These goals have all been tackled in this work and a review of the progress made plus a summary of the chapter findings and conclusions are displayed below. This also makes general comments and remarks regarding the approach to the different aspects of the research.

7.3. Chapter Findings

Chapter 2 and 3, as well as synthesising the main theories of agglomeration, also gave a good indication of the types of characteristics associated with the subject. This is an important task and one that is imperative if a new theoretical contribution is to be made.

The research in chapter 3 especially from the work of Hoff and Chen beautifully sum up the current thinking within the field with the title of their 2006 paper "Whither or Not Industrial Cluster: Conclusions or Confusions?" The work compares the vast number of competing theories vying for supremacy. Gordon and McCann (2003) cited Hoff and Chen (2006) "no single cluster concept is able to explain the emergence, existence or decline of all industrial clusters". This contribution would suggest that there will never be a cluster theory capable of explaining everything. But maybe that is the problem with the notion of a cluster, clusters maybe thought of as only the visible effects of agglomeration. This author suggests disconnecting the two terms, something which has yet to be achieved in this field. Agglomeration has become a very different concept than clustering and yet their foundations remain almost the same.

Identification of clusters was the other major issued tackled in these sections. The many different techniques employed including numerous studies were detailed. What the work found was some measures such as the LQ have become a dominating characteristic of any cluster study. The work purposely focused on the quantitative techniques instead of the less generalisable qualitative studies. This was to not downplay their importance but the lack of agglomeratory evidence present was found to be negligible in this work.

Statistical frameworks are by no means the only way to identify clusters and indeed as noted by Rosenfeld (1997) authors who believe they are, often leave themselves open to criticisms. However again this work when distinguishing between clusters and agglomerations suggests that the identification of both should be seen as separate tasks. With this in mind this work wishes to leave the notion of clusters aside and instead focus on agglomeration.

The first half chapter 4 carried out an investigation into the use of different spatial values for the denominator when calculating LQ's. The studying constructed LQ's for SIC's 15-36 using both Wales and the UK as the denominators. The results showed in some cases a significant difference between the two. This creates somewhat of a problem when deciding on what denominator to use. If one wishes to use the standard arbitrary cut off point of 1.25, depending on the denominator chosen any given area may or may not have a significant specialisation. This implies that specialisation is only a relative measure; as such this is an important realisation to be made regarding the LQ technique.

Chapter 5 set to ascertain what the present level of agglomeration was in South Wales focusing on the manufacturing sector. The results show a region highly diversified but yet with substantive specialisations. Firm size as well as intensities of manufacturing point to clusters, identified from the De Propris methodology, however the use of 4 digit data has created major problems. After considering in detail the work of De Propris (2005) it was found, when using 2 digit data, around 8 SIC's were identified as being highly specialised per TTWA.

Comparing this value to the 4 digit data used in this research it was found that on average 33 SIC's were found to be highly specialised per TTWA. This was a surprise and created somewhat of a problem, and offers little clarity on precise identification of specific industries thought to be agglomerated.

Chapter 5 of the work sought to bring a more rigorous framework to the analysis of LQ data based upon the problem identified in the previous chapter. To enable more clarity to be achieved from using 4 digit data another method must be sought to find a way of including a measure of significance rather than simply relying on arbitrary cut off points. The method demonstrated has shown excellent results for the highly disaggregated data used within this study. That the sheer numbers of sectors which, after analyses, are no longer considered as statistically significant is a testament to the usefulness of this statistic.

The method outlined in this chapter has yielded good results both from an academic as well as a policy point of view. The basis of the model is ingrained within traditional economic theory and well as being informed through an intuitive framework. The key to its construction and thus its results relies on the use of applied data, which offers a true insight into the industrial make up of an area.

In chapter 6, when using highly disaggregated data, as was done in this project, the need to create clarity in the data set is without doubt the greatest challenge. As noted before previous work which has opted to remove so called "non- compliant" industries seems to this researcher to be a poor method of analysis.

The decomposition approach allows a more detailed position of analysis to be adopted rather than trying to make gross generalisations about individual sectors. The assumptions made have tried not to be unrealistic or more grossly unrealistic suggestions about agglomeration. Like most economic models assumption is the important dynamic in the analysis. These assumptions have tried to be as realistic as possible to avoid the heavily theorised approaches used in other studies of this type.

However the limitations, notably the lack of interaction between individual sectors creates a problem as regards the precise nature of the agglomeratory forces. The proposition of agglomeratory waves is not a new notion but their travel through economic space as outlined in this chapter is. To prove the existence of these forces is a significant challenge. This work has attempted to see the subtle tell tale signs that these waves leave behind along their journey, whether it is possible to take this notion further remains to be seen. However the goal of this study is to offer a new method of analysis rather than a tool for qualitative understanding. This does not mean that this method could not be incorporated into any such analysis. The results for South Wales are very positive and offer real potential for further economic study, in particular focusing on the identified agglomerations as a starting point from which individual sector studies may be carried out.

Probably the most important and interesting contribution to this chapter is the new theoretical construction of agglomeration. The "wave" theory formed may have its origins in the physical sciences but the notion it maintains regarding agglomeration is deeply embedded in economic theory. The wave concept goes some way to explaining how some industries end up concentrated in the same area of economic space and others do not.

To proof the theory is another task. To this point agglomeration has been a much debated idea and empirics, like anything else in the field, are not straight forward. It is hoped that further empirical investigations in particular in chapter 6 can begin to help bring a greater understanding to the theory proposed here.

The second part of chapter 6 took a step back from the analysis conducted in the previous chapter and began to look again at the underlying measures used in agglomeration analysis. There was a particular focus on the agglomeration analysis of Ellison and Gleaser (1997). The work examined relative measure of concentration and in doing specifically highlighted their relative weaknesses in establishing a measure for agglomeration. After an extensive review of literature, a new measure was constructed based upon the previous work done. The C statistic allows the measurement of two effects of agglomeration intra industry trade and specialisation to be combined into one test. The scale formed can be both negative and positive emphasizing the fact that industry can have strong or negative strengths in agglomeratory forces.

7.4. Policy Implications of the Research

Analysing agglomeration and its relationship to both national and regional government policy has been considerable over the past decade. However its understanding and use from an economic development point of view could have been questioned, in particular over the continuing notion of clusters being seen as noted in this work as a tool rather than as a genuine economic phenomenon. If this course of action continues, the notion of a cluster will continue to erode the underlying concept of economic agglomeration.

Policy must begin to understand the limitations of clusters and actively try to look at the notion of agglomeration instead. If one considers the Marshallian understanding of agglomeration it is as applicable today as it was when it was first written. Instead of focusing on the outcome, that is a cluster, governments should concentrate on the development of positive externalities in spatial economic planning. Policy should be adapted to help encourage agglomeratory effects not to have clusters as such.

Policy makers should acknowledge the original work of Marshall (1880) and consider his three major influences of positive externalities, knowledge spillovers between firms, specialised inputs and services from supporting industries and finally a geographically pooled labour market for specialised skills. What many policy makers could be accused of doing, up to this point, is trying to build clusters from scratch based upon industries which they believe will be the "next big thing".

For example the notion of biotechnology and optoelectronics in Wales being the cornerstones of the Welsh Assembly Governments (WAG) clustering strategy, based upon market projections of demand for this form of industry over the next 40 years. This ignores the notion of existing specialisations and agglomeration (identified in this study as in manufacturing of food and beverages SIC 15, or manufacturing of electrical Machinery SIC31) and instead focuses on growing new industries. The risk of this is the lack of integration into the wider economic structures of Wales and more worrying is the Porterian thinking of cluster dynamics. A consultation document produced by the WAG: "The National Economic Development Strategy" (2003) speaks at length regarding cluster policy in Wales.

One of the fundamental purposes of clusters identified within the document is to encourage growth in high value added industries; it goes further and suggests sectors to target:

- Aerospace, *
- Medical & diagnostic equipment and products,
- Biotechnology, e.g. organic semiconductors; Bio-electronics; Bio-metrics; *
- Renewables,
- Environmental services,
- Telecommunications. e.g. Peta/yotta bit routing devices
- ICT/software. e.g. Wearable computing; Robotic agents;
- Display technologies; Battery components; Quantum computing.
- Customer contact centres,
- Optronics, *
- Niche tourism
- Media, creative and culture related sectors.

These targets are ambitious, those industries marked with an asterisk are also identified in the DTI (2000) report as being clusters present in Wales. The interesting thing to note here is that not one of the other 7 clusters identified in the DTI work is included in this consultation document. The even more confusing part of the consultation document is the acknowledgement by the authors that location is not an important factor in these industries.

This is completely contrary to the concept of agglomeration which implies location being at the heart of the phenomenon. The document recommends that after setting policy to encourage development of these industries a cluster mapping exercise should take place. This idea seems to be back to front, indeed setting targets before understanding the depths of the existing recourses seems to imply that cluster development is an exogenous rather than endogenous activity. If we take a closer look at the industries the striking feature is the diversity with which the government is trying to put into the Welsh economy. This emphasis on diversification is contrary to the notion of specialisation and as Porter himself notes, not every area can specialise in everything, and yet government policy here is attempting to latch on to numerous growth industries.

7.5. Policy Implications and the Results of this Research

This work has generated new insights into both agglomeration and, due to its use as a test region, the industrial make up of south Wales. Both of these have policy implications beyond this work.

The new methods constructed within this research for the first time allow policy makers to say with a degree of certainty to what extent an industrial specialisation is significant to a region. They go further than that with the use of the Crawley statistic by allowing governments to measure the level of agglomerations present within the industries of a nation. These measures when combined together give a powerful tool in designing both regional and national economic policy focusing on specific industrial sectors.

For Wales the results of these analyses have highlighted some familiar sectors such as automotive (SIC 35) and metal working (SIC 27) industries as having a high degree of agglomeration, the analysis has also identified sectors such as wood manufacture (SIC 20) and publishing (SIC 22) exhibiting low levels of agglomeration. When these new results are compared with the WAG cluster strategy there seems to be a startling dissimilarity. Industries which the Welsh assembly see as being in clusters and those industries exhibiting any form of agglomeration are not one and the same. It would seem that the results of this work would be best disseminated to those in power in the region in the hope that economic decisions maybe better informed.

7.5. Future Research

The tools introduced in this work are merely the starting point and by no means the end in agglomeration analysis. The theory constructed in chapter 6 of agglomeratory waves is a fundamental change in the thinking regarding the subject.

As with any new thinking there must be a period of reflection, in particular this work wishes to begin to better understanding how these agglomeratory waves interact and if indeed the relationship between their existence and economic growth is significant. To do this an in-depth econometric analysis is required, to estimate whether the relationship proposed in this work is significantly better in explaining agglomeration than previous attempts. The exploration could be further enhanced, by using this theory as a starting point and conducting qualitative research to fill in some of the missing pieces of information.

The goal of any piece of research is to fully understand a topic not to simply derive meaning where none truly exists. Although the theory in this work is just that the idea proposed as shown some merit in explaining the picture in South Wales accordingly it would only to right to see if this extents to other regions and indeed other parts of the globe. This author proposes the construction of an index of agglomeration, which is measuring the relative agglomeratory force based upon the C statistic for all industrial sectors and using it as a guide to how attracted certain industries are to one another.

The other area of further study would be to investigate the relationship of further spatial aggregation and disaggregation on the decomposition thinking formulated in chapter 5. It may be useful to try using different spatial scales with the decomposition idea and investigate any pattern variations between the number of α and β. The other interesting aspect is the fact that this notion of agglomeration does not rely on any arbiter cut off points for either firm size or LQ's thus could provide a more robust statistically significant agglomeration identification technique.

7.6. Contribution to Knowledge

This work has introduced two new methodological approaches into the study of agglomeration; the decomposition thinking and the C statistic. It has also perfected the use of existing tools, namely the LQ confidence interval onto never before used disaggregated data. This has provided evidence to both the positive application of these techniques as well as the cautionary caveats needed when using these statistics.

What it has also done, is to put forward a new theoretical standpoint regarding agglomeration. The notion of waves of industry existing across economic space is a new concept within this form of regional study. It is hoped that further research on this theory will yield even greater understanding of the economic world around us.

7.7. Final Thoughts and Summary

This work has not closed the debate on clusters and agglomeration, in fact if anything it has reinvigorated the whole field of study. It is hoped that it will inspire a new thinking and further research into a field with substantial prospects, and yet to this point confused and complicated. Clusters may not be the answer to regional development, neither may they be the future of manufacturing industries, but what they are is a fascinating phenomenon steeped in history and well and truly a fixture of the modern economic landscape. Agglomeration or clusters: is there a difference? Something there may never be a consensus on, but this author hopes that it is a debate not left to the annals of history.

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