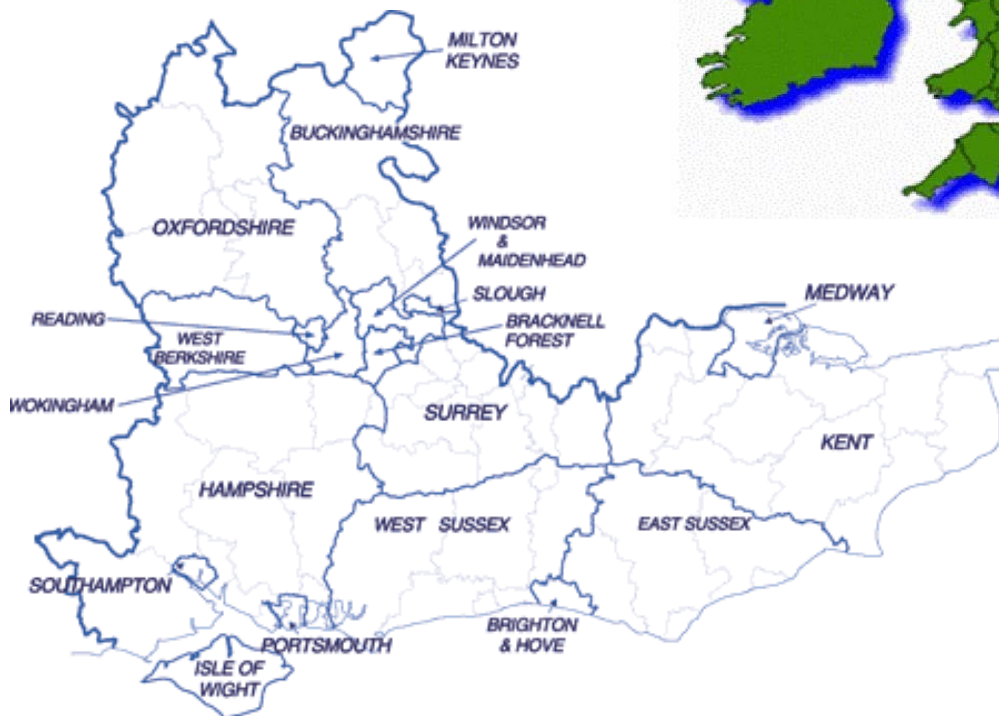# CLUSTERS IN THE
SOUTH EAST OF ENGLAND

Authors and Contributors:
Dr. Emanuela Todeva, School of Management, University of Surrey

Specialist Consultants:
Donka Keskinova, Scala, Co., BG

South East

MILTON
KEYNES

BUCKINGHAMSHIRE

OXFORDSHIRE

WINDSOR
&
MAIDENHEAD

SLOUGH

READING

BRACKNELL
FOREST

MEDWAY

WEST
BERKSHIRE

WOKINGHAM

SURREY

KENT

HAMPSHIRE

WEST SUSSEX

EAST SUSSEX

SOUTHAMPTON

PORTSMOUTH

BRIGHTON
& HOVE

ISLE OF
WIGHT

This report is intended as a basis for discussion. While every effort has been made to ensure the accuracy of the material in this report, the authors and the sponsors will not be liable for any loss or damage incurred through the use of this report.

CONTENT

LIST OF TABLES, FIGURES, GRAPHS AND MAPS

---

[*] ICT = information and communication technologies

[†] R&D = research and development

[‡] Strength of ties is measured by the number of firms that declare simultaneously a pair of industry codes, and is calculated according to a formulae described further in the methodology section (Formulae 1)

1. Clustering of Firms at Regional Level: Key Points

- Research on clusters has been driven primarily by various policy initiatives that target government intervention for economic development, innovation, and growth. By their nature, cluster policy initiatives focus on specific industries and regions where there are no established criteria for defining either industry or geographic boundaries. This report introduces an alternative approach to cluster research, which is based on clear definitions of industries, regions, and sub-regions, and a comprehensive dataset of the portfolio of activities for the entire population of firms, registered in the South East of England, UK. The originally designed multi-stage methodology utilises multiple and complementary statistical methods for mapping cluster membership and analysis of intra-cluster and inter-cluster relations.

- The clear geographic boundaries of the region of South East of England allowed us to select the entire population of registered firms (as for September 2002), and to allocate the entire regional population of firms into clusters according to their broad industry specialisation and diversification.

- The US industrial classification system was selected for the purpose of our analysis as it provides much richer data on the industry specialisation and diversification of firms, compared with the data recorded by the UK classification system[§]. An illustration of the difference between the two systems is that only 3 % of the firms in the database report two or more UK SIC codes, while 76% of the same population of firms report two or more US SIC codes. We built the database of the regional population of firms containing both UK SIC codes and US SIC codes in order to provide for comparison with previous attempts to identify clusters in the South East of England.

- The analysis of inter-industry relations is conducted on the basis of firms registered in the region that report operations in two or more industry codes. Internalisation by firms of activities across different industries is treated as evidence of an inter-industry relation based on integration of different industry activities by firms through acquisitions or internal growth. Inter-industry relations that are exhibited in the diversification portfolio of firms are

---

[§] UK SIC (UK Standard Industrial Classification) and US SIC (US Standard Industrial Classification).

interpreted as vertical and horizontal integration of activities within and across value chains. Structural maps of these value chains are produced for each identified cluster.

- The main research task for cluster mapping required that the source of information provided systematic data across the entire population of firms. For this purpose we used a business data source Amadeus – which is an online data-source produced by a company Bureau van Dijk, containing all registered firms in Europe ($\approx$ 5 mln firms by September 2002).

- The database was subjected to analysis using a multi-stage methodology for cluster mapping. Two independent cluster maps for the regional economy were produced – one based on the UK SIC codes, and the other – based on the US SIC codes. The structure of individual clusters and the entire regional economy was visualised with the cluster maps based on US SIC codes and using network analysis techniques with the network analysis software UCINET.

- The 31 clusters in the South East of England, identified with this research represent the entire regional economy without a distinction between local services vs. national or global operations, and between resource-based clusters, local clusters and export-oriented or traded clusters (DTI, 2001, Porter, 2001). The two cluster profiles of the regional economy based on UK SIC and US SIC data were compared, which led to a more precise final allocation of firms into clusters.

- The research confirmed that there is substantial horizontal and vertical integration across industries, which is demonstrated by the horizontal and vertical diversification of firms. Firms have absorbed large parts of the value chain in their own portfolio of operations.

- When a large number of firms show a repeated pattern of diversification, this is treated as an evidence of synergies that derive from this diversification of operations, and an evidence of value chain linkages internalised within firms. Value chain linkages in this context represent inter-industry linkages and are exhibited in each cluster map. The most typical value chain linkages, internalised by a significantly large number of firms in each cluster represent the core structure of each cluster.

- The number of clusters identified for the region is relative to the statistical criteria that were chosen as part of our methodology for the clustering of firms. The subsequent network

analysis of inter-industry relations within clusters reveals that while some clusters are coherent entities of firms, others are fragmented agglomerations that can be subdivided into smaller sets of interlinked industries that remain relatively isolated from the rest of the regional economy.

- Research reveals also that a significant number of clusters are interconnected by a number of industries – as an evidence of convergence and synergies across value chains that companies have already identified and captured within their portfolio of operations. Inter-cluster connections and relations are evidence of activities that take place outside of the main value chains, or evidence of activities in industry areas that feed into different product value chains.

2. Executive Summary

- One of the currently recognised strong trends in the economic development literature is that firms align and collaborate in value-added activities, seeking efficiency from specialisation and from capturing synergies and complementarities based on sharing resources horizontally and vertically. It is known that while small and medium size firms with limited capabilities have more incentives to collaborate, large and well established firms tend to seek more control of their operations. The larger the firms, the more likely they will attempt to acquire control of critical value-added activities upstream and downstream, which leads to the related diversification of their portfolio of operations into other industries. Inter-industry relations emerge within the portfolio of operations of diversified firms. Overall, inter-industry linkages can be both external, i.e. based upon supply relations between firms, and internalised within the portfolio of activities of individual firms.

- Active cooperation between firms generates inter-firm relations that settle in a variety of regional and industrial agglomerations and concentrations that are associated with clusters. Regional concentrations are identified as regional clusters, and industrial concentrations are known as industry groups. Regional clusters of interlinked firms and industry groups of diversified companies are offering alternative options to specialisation vs. diversification, and concentration vs. dispersion of business operations. Firms are actively re-designing the boundaries of their operations with strategic decisions on their portfolio of activities. Strategic decisions and choices such as internalising and in-sourcing or externalising of activities are actively changing the boundaries of firm specialisation. Integration of specialised activities within the portfolio of operations of individual firms creates diversified companies that operate in multiple industries. Companies that exhibit the same diversification of their portfolio of activities form industry groups that control specific parts of the value chain of individual product categories. In our cluster maps these industry groups are exhibited as specific components and segments that demarcate a pattern of diversification among a significantly large group of firms.

- Research on clusters has focused on why firms co-locate in a particular geographic area, and what do they seek in collaborative relationships with public sector organisations,

with government agencies, or other knowledge institutions and business service organisations. Inter-firm relations of this kind rest on strategic decisions and choices made by individual firms regarding the efficiencies that can be captured from specialisation of operations, from the scale and scope of their diversification, and from the coordination of input and output flows. At the same time methodologies for mapping of clusters are using mainly inter-industry relations assuming that this includes transactions and collaborations between firms. Inter-industry relations are also used as indicators of value-chain interconnectivity and links between input and output markets. Hence, intra-firm diversification of operations exhibited within and across value chains is a critical indicator for cluster boundaries and for inter-industry relations within and across clusters.

- Among the strategic choices that lead to the emergence of cluster agglomerations are: location and spread of operations; specialisation and diversification of the business portfolio; horizontal and vertical integration of activities within firms and across value chains of inter-connected firms; operational activities across firm borders; establishment of partnership agreements; actively capturing value from externalities such as localised labour market, government policies, and quality business infrastructure. In this rich set of strategic motives that generate agglomeration effect, methodologies for drawing cluster boundaries and analysis of cluster dynamics are lagging behind.

- This report presents the results from research which has developed a comprehensive methodology for mapping of cluster activities, drawing of cluster boundaries, and analysis of intra-cluster and inter-cluster relations within the contained geographic area of the South East of England. As such, this project draws upon the knowledge of previously conducted research by DTI on the clustering of the UK economy (DTI, 2001), on Porter and the survey of competitiveness (Porter, 2001); the work by OECD on sources of innovation (OECD, 2001); and the IMD and the World Competitiveness Yearbook, containing evaluation of 59 countries and some large and dynamic regions, based on 320 competitiveness criteria (IMD, 2003).

- The cluster project in the South East of England was conducted in three different stages. At the first stage we built a database of the entire population of firms in the region with their portfolio of activities. During the second stage we developed the multi-stage methodology for cluster mapping which included identifying cluster structure and

boundaries and allocation of firms in clusters. The third stage included cluster analysis that focused on definition of the core intra-cluster value-chains and the core structure of inter-industry relations; on mapping of the scope of cluster activities; on analysis of cluster overlaps; and on comparison of clusters. In addition, during the third stage, the data allowed us to identify how each cluster contributes to the employment and the wealth creation in the region, and whether there is a concentration of specific cluster activities at sub-regional level. The results from these three stages are presented in the subsequent sections of this report.

3. Theory of Regional and Industrial Clusters

Key Problems with Cluster Research

Most of the literature on clusters recognises that at present there is a lack of common definition as to what clusters mean and what are their common features. Research on cluster cases still lacks common methodology for identifying cluster membership and cluster boundaries. There is also a lack of methodology for verifying cluster results, and hence all recent findings on innovation and creativity in clusters or cluster growth and dynamics still can not be used for comparisons. Clusters are inherently different by their industry composition and socio-political and institutional context. Clusters also show different dynamics, which has been used by some authors to distinguish between localised vs. traded agglomerations, and which has raised questions over the negative consequences of regional concentration and the lock-in effect of regional specialisation. Every country/region has a unique cluster blend and the intra-cluster and inter-cluster dynamics is determined very much by this unique blend.

Research has confirmed that there is no ideal type of cluster, and hence, it is difficult to direct policy intervention. Industrial clusters may transcend various geographic areas and geographic clusters may cross many industry boundaries. The overlap between geographic clusters and industry agglomerations has become more profound in mature market economies, where the integration between primary, secondary and tertiary economic activities has generated some specific concentrations. Empirical research also has identified that both high-tech and low-tech clusters can induce product and process innovation, which however are driven by different mechanisms. High-tech clusters tend to be more global in reach, while low-tech clusters tend to be more localised and to have more complex and advanced innovation processes. This confirms that the field of regional and industrial clusters is still in its infancy, which carries many unanswered questions for future empirical investigation.

In this context, we were looking at some landmarks in the literature that can establish the foundations for cluster analysis – both theoretically and methodologically.

Definitions of Clusters

- Clustering is the tendency of vertically and horizontally integrated firms in related lines of business to concentrate geographically (OECD, 2001).

- Clusters are geographically proximate groups of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities (Porter, 1998).

- Clusters are groups of business enterprises and non-business organisations for whom group membership is an important source of individual competitive advantage. Buyer-supplier relations or common technologies, distribution channels or labour pool, bind the cluster together (Bergman and Feser, 1999).

- Clusters are networks of production of strongly interdependent firms, linked to each other in a value adding production chain. In some cases they encompass strategic alliances with universities, research institutes, knowledge-intensive business services, bridging institutions (i.e. consultants, brokers) and customers (Roelandt and den Hertog, 1999).

In review of these definitions, we have synthesised a new statement that captures the essence of what clusters are, and the principles that lead to their formation:

> **Clusters are agglomerations of firms, co-located in a geographic area, connected by value-adding activities, and that benefit from localised access to input/output markets, to infrastructure, and to environmental coordination via institutions and policies from the public and the private sector.**

Most of the research on industrial clusters is focused on the co-location of firms in geographic regions, and its impact on local labour market and local economic growth (Piore and Sabel, 1984, Doeringer and Terkla, 1995, DTI, 2001). The theorising of clusters diverge from the main stream economic assumptions that explain sources of competitive advantage as being based within the firm. On the contrary, cluster theories look at external economies – economies of scale, of scope and agglomeration economies - combining both vertical and horizontal specialisation and integration within and between firms.

Types of Clusters and Cluster Dynamics

The original concept of clusters refers back to the Marshalian notion of 'localised economies' (Marshall 1919, 1927), explaining the dynamics of local economic activities as being induced by four key factors. First, this is the attraction of intermediaries and input providers to localised firms. Second, this is the creation of a pool of specialised labour that is employed locally. Third, this is the development and deployment of specialised machinery and technologies that concentrate related activities in one location. Fourth, this is the spillover of knowledge and technology between firms enhanced by proximity factors, where the spillover supports economic growth through learning and innovation.

Among the most dominant conceptualisations of types of regional and industrial clusters are: the notion of inter-firm cooperation in an *industrial district* localised in urban and sub-urban locales (Piore and Sabel, 1984), and the notion of *innovative milieus*, as a geographically concentrated dynamic and reproductive system of interlinked firms and government institutions, embedded in a rich socio-economic context (Aydalot, 1986).

Since then, the concept of clusters has evolve to capture a variety of industrial agglomerations consisting of: small locally owned firms *(new industrial district / NID)*; concentration of foreign subsidiaries and branch facilities of externally-based multinational multi-plant firms *(satellite industrial platform)*; regional concentration of firms that supply major corporations with various inputs *(hub-and-spoke)*; congregation of subcontractors and partners to government entities, such as defence plants, to government departments and universities (s*tate-anchored district*); and the so called s*ticky mixes'* which represent a combination of the above listed types of industrial and geographic clusters of firms (Pandit and Cook, 2003). Other typologies of industrial clusters include: *vertical production chains*; aggregation of *input/output connected sectors*; and *business networks* - or constellations of firms which are not necessarily geographically concentrated, but are interconnected through industrial linkages, technological dependencies, and stable resource flows.

As there is no preferred level of analysis, cluster analysis can focus at a macro-level of national patterns of industry specialisation and industry groups; at meso-level of inter-industry and intra-industry vertical and horizontal linkages; and at micro-level of inter-firm supplier or buy-sell linkages and the agglomeration of firms accessing input or output markets in particular geographic location (Feser, 1998). In all cases, the economic benefits to firms and to regions or

national economies derive from specialisation, division of labour, and from coordination and collaboration rather than from competition.

It is widely recognised that regional agglomeration and specialisation of firms reduce transaction costs and maximise the benefits from technological, market and other shared externalities that underpin economies of scale and scope, and increase the returns to firms. However, research has not produced strong evidence whether the drivers behind clustering of firms derive from the local economic conditions, i.e. from a bundle of locational advantages and positive economic externalities, or from firm's strategic choices, and from firms' improved co-ordination of resource flows through industrial and technological linkages, that are captured by the value-chain activities and are merely observed in regional agglomerations.

Among the fundamental assumptions, accepted by all streams of cluster theorising, are that sophisticated division of labour and specialisation are natural processes that occur with the growth and expansion of markets. The simple input-output relations between firms require coordination that can be either internalised within the firm, or externalised via supply-chain contracts. Coordination outside the boundaries of the firm naturally requires cooperation, exchanges and sharing of resources that generate spillovers and synergies, learning and innovation, or further economic externalities that can be accessed only via inter-firm relations and interactions. Proximity between firms, such as geographic, technological, organisational, socio-cultural, cognitive, or institutional – enhances inter-firm linkages and produces externality effects that can be captured by the interacting organisations (Boschma, 2005). The business environment in which firms operate is heavily affected by the public realm via business policies, by the labour market condition, the quality of the human capital, or by the basic infrastructure.

In this broad theoretical context, our choice for a clustering methodology was influenced by the following principles:
- Cluster agglomerations are groups of organisations co-located in a common geographic, or technological (industry) space, that are linked together in close input-output relations; that have access to common infrastructure and associated institutions; and that share access to specialised input/output markets;
- Such linkages are also internalised within firms through mergers, acquisitions and endogenous firm growth, and can be observed as part of the firm's diversified portfolio of activities and operations;

16

- Industrial agglomerations occur because of random factors; because of access to customers or to resource inputs; or because of path-dependency that emerge as a result of constraints and opportunities related to the mobility of factors of production – resources, labour, capital, and technology;

- The geographic concentration of competitive firms in a location, from a strategic perspective, is seen as a strategic response to environmental pressures and incentives;

- Industrial and technological linkages between firms provide the fundamental reason for interactions, transactions and any form of inter-firm relations;

- Inter-firm relations represent inter-industry input-output relations that describe a chain of value-added activities, and capture synergies across the value-chain of individual products;

- Co-location of firms in particular product markets (or industries) is a measure of firms' specialisation and differentiation. Hence clustering of related firms according to their industry specialisation/ diversification is more adequate than clustering of industries represented in a region;

- The portfolio of US SIC codes that a firm reports represents a combination of related and unrelated diversification of operations, and captures the diversification of firms' capabilities on the value chain;

- Innovation, investment and productivity growth are directly associated with firms' strategic choices to diversify their business operations, and indirectly associated with concentration of industries in specific locations.

As a result of accepting these principles, we approached the task to identify clusters in the South East of England from the perspective of clustering of the entire regional population of firms according to their specialisation and scope of diversification. The scope of diversification was measured by the industries that firms reported having activities in.

The portfolio of activities for each firm was interpreted as internalisation of control over the value-chain through forward and backward integration. Inter-industry links or value-chain links were mapped as dyadic relations where significant number of firms declared operations in each pair of industries. Hence, the structure of the regional clusters incorporates inter-industry links that firms have identified as generating synergy under common ownership. Following from that principle, connected industries are those that are reported simultaneously by a significant number of firms in pairs as part of the firms' portfolio.

The clusters in the South East of England represent industry clusters of firms, co-located in the region. The structure of these clusters is visualised via the interlinked related and unrelated industries that generate complementarities for firms associated with common control and coordination. The map of these interlinked industries represents interconnected activities along the main value chain that hold each cluster together.

Support to Cluster Research

Cluster research is an academic field that contributes to debates in multiple disciplines (economic geography, industrial economics, industrial organisation, strategic management, business policy, industrial policy, and economic sociology). It is not surprising that in this interdisciplinary context there is no established definition for what cluster is; no established methodology – how to identify clusters; no agreed theoretical framework - to underpin cluster research; and no consolidated empirical basis for comparative analysis of clusters. Among the most acute questions for cluster research are: a) what is the right level of cluster analysis and what kind of techniques are most appropriate; b) are cluster policies a legitimate form of government intervention; c) are today's clusters a problem areas for tomorrow's growth; d) can clusters learn; e) how to measure success of clusters?

Although there is clear evidence of the benefits of cluster economies (Anderson, 1994, DTI, 2001), research has not been able to identify what triggers the geographic co-location at the first instance, and to what extent agglomeration economies can be attributed to individual clusters, or to overall regional competitiveness (IMD, 2003). The problem is more acute for explaining why firms invest in the same market segment (specialisation of clusters), and why they differentiate in the same product field entering head-to-head competition.

As part of the main project, we aimed to develop a research support infrastructure which can address some of these questions and can stimulate future cluster analysis and cluster development. An exclusive databank with publications and research papers was developed. It comprises of selected articles from over 130 academic journals. In addition to the published articles, a number of research papers available online were assembled from key research centres that specialise in research on clusters, industrial organisation and regional economic development. Overall the databank consists of over 2,000 publications, organised in a conceptual map. The main categories that represent the bulk of publications and the development of the field are: cluster theory, cluster methodology, cluster and industry policies,

national innovation systems and policies, industrial clusters, regional geographic clusters, global clusters, and clusters of small and medium size firms (SME clusters) (Fig. 1).

As cluster research is very much policy motivated, a large number of publications reflect various policy agendas, such as: cluster and industry policies, the development of science parks and centres of excellence, university research and university-industry collaboration, research and development and technology partnerships, technology management and knowledge management across firms, and the process of learning and knowledge acquisition – in firms and in clusters. In addition, a number of empirical research reports and evidence from a range of industry-specific clusters were assembled. Among the most researched clusters are: the bio-technology and bio-science, pharmaceuticals, automotive, electronics, software and the information technologies, the telecommunications, food and agro-business, and the media and broadcasting clusters.

Fig. 1. Domains of cluster research
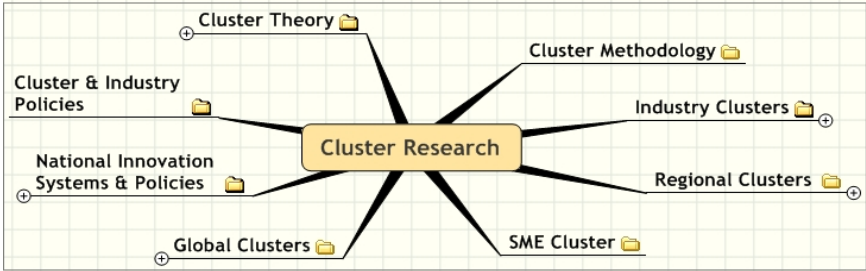
The work that contributes directly to cluster theory spreads across a wide set of issues, including: agglomeration, location and proximity; cluster and sector dynamics; industry analysis and organisation; competition and cluster competitiveness; economic growth; regional and urban development; co-evolution of firms in clusters; spillover effect in clusters; inter-firm coordination and synergies from inter-firm relations; absorptive capacity of firms; competences and capabilities shared within clusters; cluster boundaries; strategic groups; and inter-organisational relations such as alliances, partnerships and networks – as conceptualised by the organisation theory of the firm (Fig 2.).

Additional support to cluster research comes also from statistical data related to clusters and regional economic development - collected by various data sources: UK Statistics Office, OECD, Inter-departmental Business Register (IDBR), National Online Manpower Information System (NOMIS) and various trade information sources. These sources contain valuable secondary data to assist future research on cluster depth and dynamics.

Fig. 2. Cluster theory domain
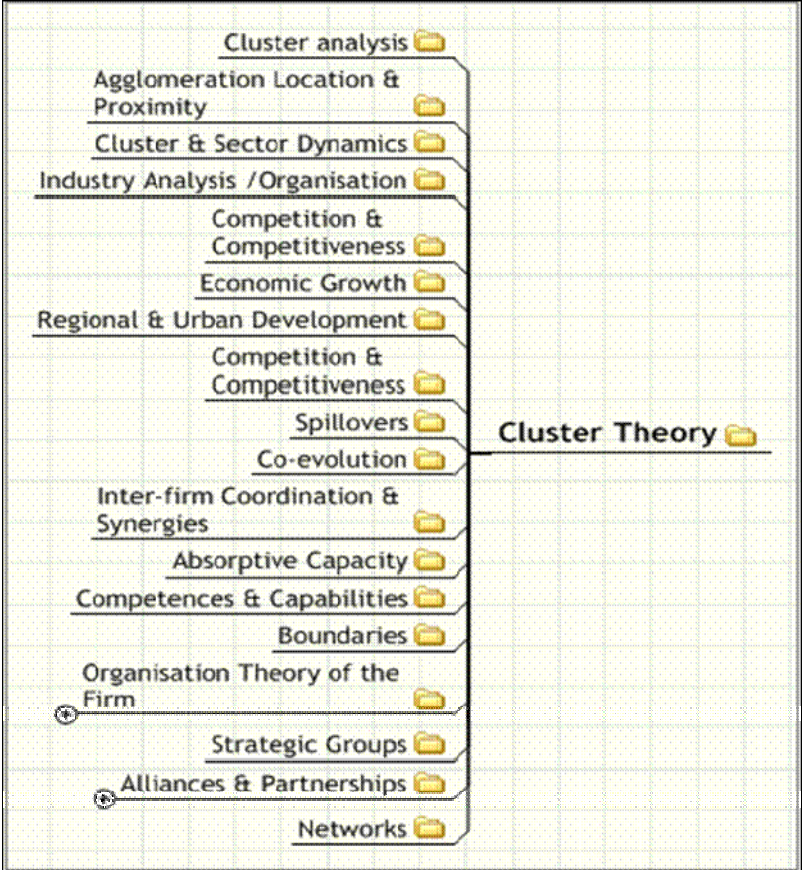
All these resources are available for a wider research investigation that aims to look at the nature of clusters, the drivers behind agglomeration economies, and the impact of clusters on local economic development.

4. Cluster Methodology

Although there is no established methodology for cluster mapping, there have been a few systematic attempts at drawing cluster boundaries and identifying cluster agglomerations. One of the most used category is the *employment location quotien* which is measured per industry and is calculated in relative terms as a proportion of the regional employment in an industry from the national industry employment figure. Concentration of employment in a particular industry in a region, which is above the average for the country is treated as evidence of industry concentration and cluster activity (Hill and Brennan, 2000; DTI, 2001).

Another methodology that attempts to cluster industries on the basis of inter-industry linkages has been using input-output tables containing inter-industry trade information (Feser and Bergman, 2000). As part of this methodology authors identify clusters of industries that are interconnected by input-output resource flows, and then look for geographic concentration of these industry agglomerations. Although this method allows complementary use of other statistics, it does not tell much about the inter-firm linkages or other regional factors that generate positive externalities. It also can not justify the geographic boundaries of the identified clusters

Alternative methodology has been developed by scholars that use interviews and questionnaires with cluster experts in order to identify the value-chain inter-firm linkages that generate synergies across the cluster space, or what is known as the cluster competitive advantage (Porter, 2001; DTI, 2001, Taylor, et.al. 2003). The main weakness of this approach is that cluster boundaries are unknown and cluster membership of firms is not justified. Such an approach can not be easily used for a comparative analysis and incorporates a number of inconsistencies both at data collection and data analysis levels.

Comparing the strengths and weaknesses of all these methodologies, it was decided that a new methodology has to be developed, that derives at cluster boundaries both from inter-industry and inter-firm perspectives, and that draws cluster boundaries in the context of the structure of the entire regional economy. This methodology is labelled '*Multi-stage methodology for cluster mapping*', and is described further in this report. It is based on the entire population of firms in the region, and contains industry data attributed to individual firms as a description of their diversified portfolio of activities. The fundamental principles of this methodology are: 1) to

allocate all firms registered in a region in clusters, demarcating clear cluster boundaries with clear cluster centres (described according to the core industry codes per cluster)[**]; 2) to produce cluster maps containing the structure of interconnected industries that form the core of the value-chain activities in each cluster; 3) to label each cluster according to its core interconnected industries; 4) to compare cluster membership based on US SIC industry codes and UK SIC industry codes and to adjust cluster labels and cluster membership in order to minimise the differences between the two systems.

The most typical inter-industry linkages internalised by firms are exhibited in the cluster maps and they represent the dominant value chain relations for each cluster. The ultimate purpose of the multi-stage cluster methodology is to identify clusters of interconnected industries based on synergies from inter-industry operations, and in the context of the entire regional economic infrastructure for individual cluster development.

Database for cluster research

For the purpose of our methodology we built a database with all registered firms in the region. The population of the regional economy was drawn from the Amadeus business data-source produced by the company Bureau van Dijk (September 2003, $\approx$ 5 mln. firms). The population of firms in the South East of England included 9 sub-regions, 182 cities, or overall 188,970 firms - with details of their activity in different industry classification systems (UK SIC, US SIC, NACE, NAICS, CSO)[††]. In addition, firm records contained data for firm annual turnover, employment, and registration details. The distribution of firms and the distribution of employment and revenue in the database is presented in Table 1.

The entire population of firms for the region have declared operations in 951 industries (by US SIC industry code). The diversification of firms varies significantly, and it is much more pronounced in their portfolio of US SIC codes. 76% of the regional population of firms have declared more than 2 US industry codes, which enabled us to identify inter-industry linkages. From this number, 12% of the firms have declared more than 13 US industry codes, and in some

---

[**] Core industry codes per cluster are defined with the application of statistical clustering technique at the first step of the multi-stage cluster methodology for cluster mapping (see description below in this section).
[††] UK SIC – UK Standard Industrial Classification System
US SIC – US Standard Industrial Classification System
NACE – Harmonised EEC Economic Activity Codes
NAICS – North-Atlantic Industrial Classification System
CSO – British Central Statistical Office

cases up to a maximum of 55 industry codes. In addition, 23% of firms have declared only one industry code (3-digit or 4-digit), which allowed their subsequent association to a particular cluster. Only 1% of the regional population of firms remained un-clustered due to missing industry data.

Table 1. Population data – all registered firms in the South East of England[‡‡]

		Number of firms	Percentage
DISTRIBUTION OF FIRMS PER SUB-REGION	Brighton	19 290	10%
	Canterbury - Medway- Tonbridge	34 271	18%
	Guildford	24 769	13%
	Milton Keynes	11 632	6%
	Oxford	14 036	7%
	Portsmouth	14 484	8%
	Reading - Slough	38 495	21%
	Redhill	16 614	9%
	Southampton	15 379	8%
	Total number of firms	**188 970**	**100%**
	Missing	0	0%
DISTRIBUTION OF REVENUE REPORTED BY FIRMS	from 1 to 10 th US$	5 287	9%
	from 11 to 100 th US$	17 912	32%
	from 101 to 500 th US$	15 839	28%
	from 501 to 10 000 th US$	12 853	23%
	over 10000 th US$	4 304	8%
	Total number of firms	**56 195**	**100%**
	Missing	132 775	71%
	Sum of revenue in th US$	**676 205 738**	
	Mean (average per firm - th US$)	11 919	
DISTRIBUTION OF EMPLOYMENT REPORTED BY FIRMS	from 1 to 5	3 867	31%
	from 6 to 20	2 706	22%
	from 21 to 100	3 792	31%
	from 101 to 200	1 280	10%
	over 200	787	6%
	Total number of firms	**12 432**	**100%**
	Missing	176 538	93%
	Sum of employment	**3 161 017**	
	Mean (average per firm)	237	
DISTRIBUTION OF 4-digit US SIC CODES REPORTED BY FIRMS	firms with 1 SIC code	9 725	5%
	firms with 2 to 5 codes	68 342	36%
	firms with 6 to 10 codes	29 628	16%
	firms with 11 to 15 codes	37 024	20%
	firms with over 16 codes (max 55)	8 309	4%
	firms with 0 codes (or missing 4-digit data)	35 942	19%
	of which - firms with 3-digit code	*34 405*	*18%*
	- firms without SIC code	*1 537*	*1%*
	Total	**188 970**	**100%**
	Mean (average number of codes per firm)	6	

[‡‡] Revenue data is recorded in thousands US$ in the database.

Only 7% of the population of firms in the database, however, reported employment data. Based on this data the total regional employment figure for the database is 3.161.017, and this represents 80% of the statistically registered actual employment for the region. 29% of the population of firms reported revenue data. Based on this data, the total revenue for the region is US$ 676 bln (data from 2001 and 2002 company annual reports).

Multi-stage Methodology for Cluster Mapping with Industry Data

Our multi-stage methodology for cluster mapping is based on the systematic application of a number of statistical methods for cluster analysis known in the statistics literature. We were not able to use one of the most established methods – 'Hierarchical cluster analysis' - due to the large size of the database. The large number of firms (188,970) and number of variables (951) required to use an alternative clustering method with SPSS software package – 'K-means'. A small test was run comparing K-means and Hierarchical cluster analysis, and the test showed over 97% overlap of results between the two methods.

The first decision that was made was to divide the total population into 6 sub-groups according to their diversification profile. We deleted permanently firms with missing industry codes (1,537 cases). Then we discarded temporary firms with a single industry code only, representing either a 3-digit code (34,405 cases), or a 4-digit code only (9,725 cases) because these cases can participate only in their own group, and can not determine inter-industry linkages.

The *first stage* of clustering with K-means was run with firms containing two or more US industry codes at the level of 400 statistical groups, which enabled us to cluster 120,350 firms in 83 independent statistical clusters. The main criteria for selecting the statistical clusters were, that they contain a minimum of 100 firms that exhibit clear pattern of diversification, i.e. minimum of two industry codes reported by all 100% of firms in that group. These core industry codes were defined as cluster centres, and were recorded and used for the subsequent stages of the clustering. The remaining firms were left unclassified in two subgroups for the next stages of clustering. These two sub-groups comprised of 'dirty clusters' (comprising of 18,756 firms) without clear cluster centres and 'small clusters' (comprising of 4,197 firms) with clear centres but with less than 99 firms in a group (usually comprising of individual firms or small groups of 10-20 firms).

The *second stage* of clustering involved regrouping of the 83 statistical clusters according to their core industry profile into 23 aggregate clusters, where overlap of core industry activities was identified. The new 23 clusters were labelled according to prevailing economic activities in them. Guiding principles in this process were the profile of each cluster and the industry groups and sectors defined under the UK SIC system for recording statistical information, as well as the clusters identified in the DTI cluster report (DTI, 2001).

As part of the *third stage* of clustering, we attempted to add to the 23 aggregate clusters, all firms with 3-digit industry code only. Seven new aggregate clusters were formed based on a significant accumulation of firms in specific 3-digit industry codes. Subsequently, we added all firms with one only 4-digit industry code to the new set of 30 aggregate clusters.

During the third stage, the 'small clusters' were re-clustered at K-means with fixed number of 50 clusters. As a result, 19 new statistical clusters were selected with clear cluster centres and a significant number of firms in each of them, and were allocated to the relevant aggregate clusters. Similar procedure was applied to the 'dirty clusters', which were re-clustered at K-means with fixed number of 200 clusters. As a result of this, 54 new statistical clusters were selected as having clear cluster centres and a significant number of firms in each of them, and were allocated to a relevant aggregate cluster.

After each of the clustering attempts we reviewed the results from previous levels of clustering. Cluster centres of all statistical clusters, aggregate clusters and sub-groups were compared. Where overlap of cluster centres was identified, sub-groups were merged. Where a new sub-group of firms appeared with significant number of cases, it was used as a basis for a new aggregate cluster, and statistical clusters and sub-groups from the second level were reviewed. As a result of this procedure, the total number of aggregate clusters was reduced to 29. At the end of the third stage, 7,939 firms remained un-clustered and were left for the fourth clustering stage.

During the *fourth stage* of clustering, the remaining non-clustered firms were re-combined into the final intermediate database for final clustering. These firms were sorted by the first ten industry codes in ascending order. As a result of this sorting, the firms were ordered first with less diversified portfolio containing two industry codes only, followed by firms containing three industry codes, four industry codes, etc., and in ascending order of the code number. These

firms were subjected to manual cluster allocation according to their prevailing profile of diversification.

All firms with the same industry codes were identified as groups and manually clustered into the 29 aggregate clusters. Following this procedure, we were able to allocate to aggregate clusters more than 5,000 firms. The remaining un-clustered 1,458 firms (with a spread of operations in two or more different clusters) were run by 'K-means' with fixed number at 50 clusters. Some of these 50 clusters were finally allocated to the 29 clusters where identification with a cluster centre was possible.

A number of ultra-diversified firms with cluster centres in more than two clusters were grouped together into one final cluster and labelled 'ultra-diversified'. Another group of firms with SIC codes that are not publicly disclosed were re-grouped into a cluster called 'non-classified'. The fourth stage of clustering was completed with all firms with industry data being allocated to one of the 31 aggregate clusters, based on the reported US industry codes.

At the *fifth stage* of clustering of firms we attempted to use the UK industry codes and to apply the same methodology. We divided the population in two groups – firms with one UK industry code and firms with two or more UK industry codes. With diversified firms we applied 'K-means' clustering at level 400, and with the firms with single code we applied frequency analysis. The cluster labels for this attempt were adopted from the DTI clustering attempt (DTI, 2001). As a result, we derived at 35 clusters based on UK industry codes.

Under the influence of the clusters based on UK industry codes, we revised the cluster composition and labels of the clusters based on the US industry codes and we were able to identify two new small clusters - 'marine technology' and 'pharmaceuticals', and to recombine 'business and management consulting services' with 'investment and business data services'. Following this procedure, the total number of aggregate clusters based on US industry data was confirmed at 31, and the cluster labels were finalised.

In order to compare the two sets of clusters based on the UK and the US industry data, we calculated the overlap between UK and US clusters and identified that there is 91% overlap, which varies between different clusters (Table 6.). We were not able to identify a number of clusters flagged in the DTI report in 2001, and we were not able to separate 'Perfume & Toiletries' from the Pharmaceuticals cluster, or the 'Environmental services' from the 'Utilities'

cluster, as the firms were closely intertwined into the wider cluster activities. We were also not able to separate clearly 'Industrial machinery' from the 'ICT and electronic manufacturing' activities, as there is a coherent core value chain that holds all these industries together, and there are too many diversified firms that operate in both areas. At the same time, we were compelled to merge two agglomerative clusters 'Investment & business data services', with 'Business and management consulting services', creating the largest cluster in the region. This agglomeration of industries subsequently in our cluster analysis proved to have a common and highly integrated core (see Map. 23.).

Methodology for Cluster Analysis

We distinguish between cluster mapping and cluster analysis as these are two distinctive parts of the process of advancing our knowledge on regional and industrial clusters. While cluster mapping aims to demarcate clear cluster boundaries and cluster membership, the subsequent cluster analysis aims to identify stable intra-cluster and inter-cluster relations between firms and industries. The key questions that our cluster analysis addresses are:

- what are the inter-industry relations that bond certain industries together in a cluster;

- what product and industry value chains can be identified in individual clusters, such as inter-industry relations that are part of a vertical integration within and between firms;

- how to represent and analyse the core structure of clusters and how to demarcate between the core and the periphery of a cluster;

- what is the core structure of a cluster that supports the range of core and supplementary cluster activities;

- which industries participate in the core structure of individual clusters, and which industries play a supporting role to cluster activities;

- which industries connect different clusters, cluster-segments, and sub-groups of firms;

- what is the employment and revenue profile of each cluster as evidence of its role in the regional economy; and

- what is the concentration of cluster activities in different sib-regions in the South East of England.

Most of these questions crystallise in five different methodological approaches to cluster analysis that we undertook as part of this research:

1. Analysis of the core structure of individual clusters and the leading inter-industry relations within individual clusters.

2. Analysis of the inter-cluster relations in the context of the entire regional economy in the South East of England.

3. Comparison of clusters based on cluster-specific statistical indicators such as cluster employment, revenue, size, and industry composition.

4. Analysis of the specific location of clusters per sub-regions in the South East of England.

5. Comparison of clusters based on two different clustering attempts – with US SIC industry data and with UK SIC industry data.

For the in-depth analysis of intra-cluster, inter-cluster, and inter-industry relations we applied network analysis techniques with weighted graphs and almost all of our methodological approaches to cluster analysis have been developed for the use of the network software UCINET that produces visualisations of various relations. For different research purposes we used different matrices (1-mode and 2-mode) and different methods of calculations of the weighted graphs (by number of firms and by calculated coefficients).

The first approach aimed to identify the core structure of individual clusters by mapping the relations between industries. Each individual cluster map describes the set of the most significant inter-industry relations that form the core structure of the cluster. An inter-industry relation or a link between two industries is defined by a firm that have internalised the activities and hence declared both industry codes. For the purpose of this analysis we developed a 2-mode matrix for each individual cluster containing cluster member firms with their industry data. Next, we converted the 2-mode matrix into 1-mode matrix using the 'cross-product affiliation method' in UCINET. As a result we developed a weighted cross-table based on calculations of the number of firms that have declared operations in any pair of industry codes. All individual cluster maps are produced following this methodology.

Next, we made certain decisions regarding the cut point that demarcate between the most significant inter-industry relations and the least significant ones for each individual cluster. For this decision we used as main criteria the intensity of ties per cluster. The value of the intensity of ties per cluster is weighted according to the cluster size (i.e. number of firms) and the total number of inter-industry relations for each cluster. Large clusters with dense interconnectivity suggested much lower threshold for the weighted number of intensity of ties. On average, the weighted number chosen for the majority of clusters was 5% intensity of ties defined by the number of firms that support a tie. This varied to 2% and 1% for large and dense clusters and 20% for very small and highly disconnected cluster, such as the 'Utilities' (Map 7.).

We interpreted each cluster map according to the dominant interconnected industries and the components and segments of inter-industry relations that appeared on each map. In addition, for each cluster we compared the total number of industries that determine the profile of the cluster with the number of industries that are most densely interconnected and determine the core structure of the value chain.

The second methodological approach was developed in order to analyse the inter-cluster relations and the relations between industries and clusters. For this analysis we developed a 2-mode matrix that contained the industry profile for each cluster. This matrix included all clusters with their full industry portfolio of codes, measured with the number of firms per cluster that have declared each code.

The value of each relationship between a cluster and an industry code was represented by the number of firms within this particular cluster that have reported activities within each particular industry, and this value represents the empirically observed absolute frequency (f). In addition, we calculated the expected absolute frequency (f') on the basis of hypothesis testing of the interdependency between the two variables, and we standardized the residuals using Pearson Chi² method with the formulae:

$$(f - f')/ \sqrt{f'} \qquad\qquad \textbf{(1)}$$

The final 2-mode matrix contained both positive and negative values, which was essential for the subsequent network analysis of the relations between clusters and industries with UCINET. Negative values in this case represent observations that are lower than the expected frequency and hence represent weak ties, and the smallest negative values overall represent insignificant links which were excluded from the matrix. The largest positive values are associated with the strongest links between industries and clusters, and the network analysis with UCINET was conducted only with the positive values.

In order to reduce the size of the network and to select the most significant relations we introduced two additional criteria. The first threshold was defined to distinguish between core structural industry codes and peripheral industry codes (declared by less than 20 firms from the database). As a result, we reduced the number of industry codes with over 20%, and the remaining industry codes represented the core industry codes for the region. The second threshold was defined to distinguish between highly interconnected and less connected

industries, or what is labeled 'strength of ties'. A decision was made to select the top 10% of ties between industries according to their strength, where strength is determined according to formulae (1). This selection enabled us to produce a more clear visual representation of the inter-cluster relations, and to identify those connectivity industry codes that represent strong and stable inter-cluster relations (see Map 32.).

In order to visualize better the results in Map 32, we segmented the entire inter-cluster network into 6 sub-groups that represent focused and enlarged segments of the entire map (see Map 32, segments A, B, C, D, E, F.). The use of the network software UCINET allows the production of visual representations that contain only interconnected industries and clusters by deleting pendant and single connected industries, and Map 33. represents the clear structural backbone of the regional economy. Changing the percentage of ties included in the map (from 10% to 13%) enabled us to select the industries that represent the strongest inter-cluster bridges, which we labeled 'connectivity codes' (see Map 34 and Table 3.)

The *third methodological approach* was developed to assist in direct comparison of clusters. The descriptive statistics included number of firms per cluster (Graph 1.), calculations of employment and revenue data per cluster (Table 2.), distribution of cluster per sub-regions according to the proportion of firms (Table 5.) and comparison of employment and revenue per sub-regions (Table 4.). We looked at the contribution that each cluster makes to the regional employment and revenue. The employment and revenue statistics in our analysis derive from the publicly available data included in Amadeus at the time the database was constructed (data varies between 2001 and 2002 for different firms).

The *fourth methodological approach* was developed for the analysis of the relations between clusters and sub-regions. Within this approach we employed the same methodology as for the second methodological approach described above. We developed a 2-mode matrix that contained the sub-regional profile of firms for each cluster (or the distribution of firms per cluster and per sub-region) (see Table 5). The value of each relation between a cluster and a sub-region was represented by the number of firms within this particular cluster that are registered in the particular sub-region, and this value represented the empirically observed absolute frequency (f). In addition, we calculated the expected absolute frequency (f'), and we standardized the residuals on the basis of the same formulae (1) described above. In the subsequent network

analysis of the relations between clusters and sub-regions with UCINET software we used only positive values, which enabled us to calculate the strength of ties[§§] above certain threshold.

Finally, the *fifth methodological approach* was developed in order to analyse the overlap between clusters, determined by the reported US industry codes and clusters determined by the reported UK industry codes. For this analysis and the visualisation of the relations we employed a 2-mode matrix that contained the firm membership in the two types of clusters – by US and by UK industry codes. We applied the same formulae (1) to calculate the value of individual relations between US and UK clusters, where overlap of firm membership exhibits the strength of the overlap, or the relationship between a UK cluster and a US cluster. The overlap between the two types of clusters was statistically calculated and presented in Table 6. The low level of overlap between certain clusters is explained by Map 37, showing the migration of firms between UK and US clusters. It is the migration of firms between clusters that produces the connectivity effect on Map 37.

With these transformations of the data in different matrices and multiple methodologies for cluster analysis we were able to investigate the inter-industry relations within clusters and the inter-cluster links. We were able to reveal with more depth the structural configuration of individual clusters and the industry linkages that connect clusters. These methodologies prepared the foundations for future comparative cluster analysis and for in-depth research into cluster dynamics and inter-firm relationships that emerge within and across clusters.

[§§] Strength of ties represents the largest positive values selected as the most significant ties on the bases of formulae (1) described above.

5. Cluster Maps[***]

Map.1. Agriculture & Farming

Map.2. Food Processing, Beverages & Tobacco

Map.3. Construction

Map.4. Real Estate

Map.5. Furniture, Fixture & Wood Products

Map.6. Miscellaneous Consumer Products

Map.7. Utilities

Map.8. Communication Services

Map.9. Miscellaneous Services

Map.10. Health Services

Map.11. Pharmaceuticals

Map.12. Chemicals & Allied Products

Map.13. Oil & Gas Extraction, Refining & Mining

Map.14. Motor Sport, Automotive Trade & Repair

Map.15. Transportation Services

Map.16. Trucking & Warehousing

Map.17. Transport Equipment, Aircraft & Space Vehicles

Map.18. Marine Technologies, Equipment & Services

Map.19. Industrial Machinery, ICT Equipment & Metal Products

Map.20. Software & Computer Services

Map.21. Instrumentation

Map.22. R&D

Map.23. Investment, Business & Management Consulting Services

Map.24. Finance

Map.25. Publishing

Map.26. Wholesale Trade

Map.27. Retail

Map.28. Hotels & Restaurants

Map.29. Amusement & Recreation Services

Map.30. Non-classified Establishments

Map.31. Ultra-diversified

[***] All cluster maps represent inter-industry relations internalised by a significant number of firms that have diversified their portfolio of operations across connected industries. Two industries are connected when a significant number of firms have declared both industry codes as areas of operations. The weighting of the tie varies between clusters and is determined by the size of the cluster and the cluster value-chain that generate the density of inter-industry connections. **All subsequent references to industry codes are based on the US SIC system**.

Map. 1. CLUSTER "AGRICULTURE & FARMING"
5% of ties between industry codes - based on more than 27 firms[†††]
1,769 firms
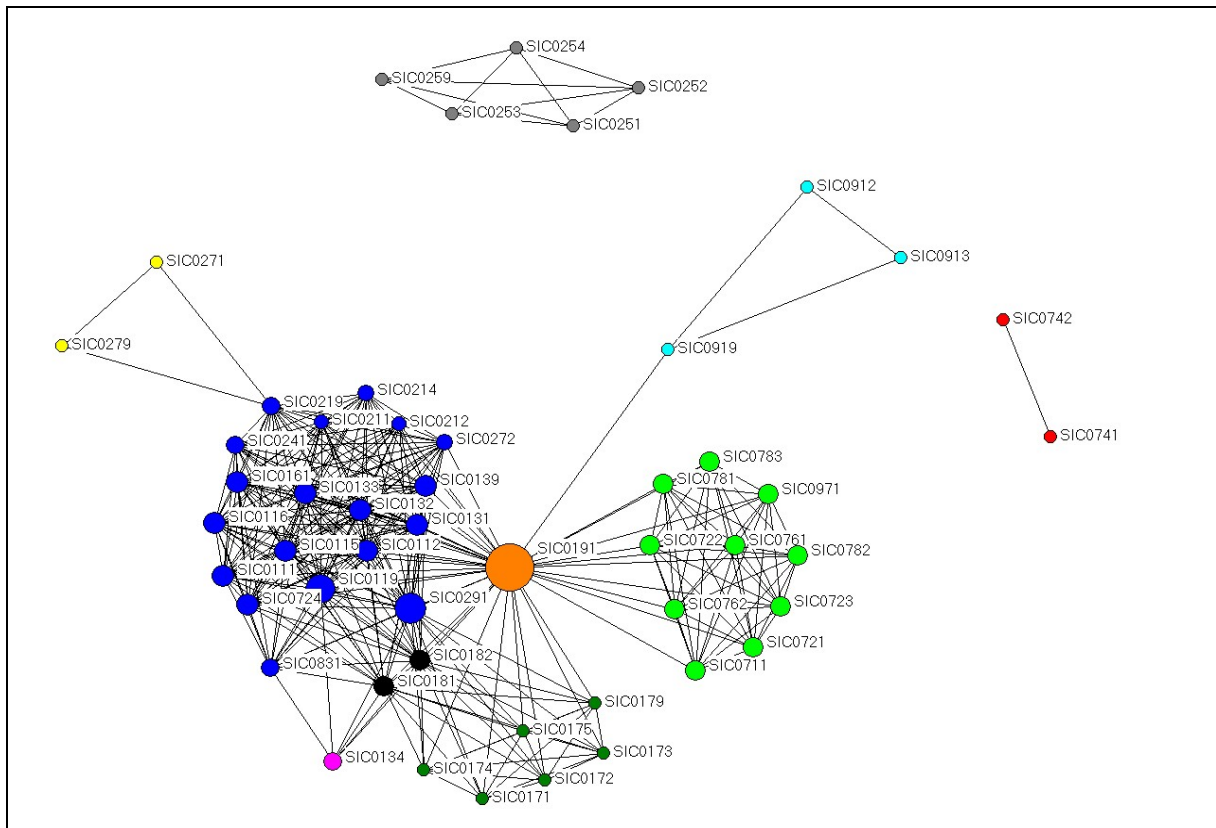
Code	Description	%
SIC0111	Agricultural Production / Crops - Wheat	23%
SIC0112	Agricultural Production / Crops - Rice	23%
SIC0115	Agricultural Production / Crops - Corn	23%
SIC0116	Agricultural Production / Crops - Soybeans	23%
SIC0119	Agricultural Production / Crops - Cash grains	35%
SIC0131	Agricultural Production / Crops - Cotton	23%
SIC0132	Agricultural Production / Crops - Tobacco	23%
SIC0133	Agricultural Production / Crops – Sugar cane and sugar beets	22%
SIC0134	Agricultural Production / Crops - Irish potatoes	14%
SIC0139	Agricultural Production / Crops - Field crops, except cash grains	22%
SIC0161	Agricultural Production - Vegetables and melons	23%
SIC0171	Agricultural Production - Fruits and Tree Nuts - Berry crops	3%
SIC0172	Agricultural Production - Fruits and Tree Nuts - Grapes	3%
SIC0173	Agricultural Production - Tree nuts	3%
SIC0174	Agricultural Production - Fruits and Tree Nuts - Citrus fruits	3%
SIC0175	Agricultural Production - Fruits and Tree Nuts - Deciduous tree fruits	3%
SIC0179	Agricultural Production - Fruits and Tree Nuts Fruits and tree nuts	3%

[†††] The percentage of ties represents a threshold that separates the most intensive ties from the rest. The number of firms per tie indicates the minimum number of firms that have reported the tie (or reported operations in each industry dyad). The size of the dot represents how many firms have operations in a particular industry, and this number is described with the percentage in the code description table below each map. The percentage in the table shows the relative weighting of each industry in the cluster. Nodes that are located in the periphery of a map usually are shared with other clusters, and hence are pulled from the centre of the cluster to the periphery. **This note is valid for all subsequent maps in this section**.

SIC0181	Agricultural Production - Ornamental nursery products	17%
SIC0182	Agricultural Production - Food crops grown under cover	17%
SIC0191	Agricultural Production - General farms, primarily crop	71%
SIC0211	Livestock - Beef cattle feedlots	8%
SIC0212	Livestock - Beef cattle, except feedlots	8%
SIC0214	Livestock - Sheep and goats	9%
SIC0219	Livestock - General livestock	13%
SIC0241	Livestock - Dairy farms	16%
SIC0251	Livestock - Broiler, fryer, and roaster chickens	2%
SIC0252	Livestock - Chicken eggs	2%
SIC0253	Livestock - Turkeys and turkey eggs	2%
SIC0254	Livestock - Poultry hatcheries	2%
SIC0259	Livestock - Poultry and eggs	3%
SIC0271	Livestock - Fur-bearing animals and rabbits	4%
SIC0272	Livestock - Horses and other equines	9%
SIC0279	Livestock - Animal specialties	4%
SIC0291	Livestock - General farms, primarily animal	37%
SIC0711	Agricultural Services - Soil preparation services	17%
SIC0721	Agricultural Services - Crop planting and protecting	17%
SIC0722	Agricultural Services - Crop harvesting	17%
SIC0723	Agricultural Services - Crop preparation services for market	17%
SIC0724	Agricultural Services - Cotton ginning	23%
SIC0741	Veterinary services for livestock	4%
SIC0742	Veterinary services, specialties	4%
SIC0761	Agricultural Services - Farm labour contractors	17%
SIC0762	Agricultural Services - Farm management services	17%
SIC0781	Agricultural Services - Landscape counselling and planning	17%
SIC0782	Lawn and garden services	17%
SIC0783	Ornamental shrub and tree services	17%
SIC0831	Forest products	15%
SIC0912	Commercial Fishing - Fin-fish	3%
SIC0913	Fishing, Hunting, and Trapping - Shellfish	2%
SIC0919	Miscellaneous marine products	5%
SIC0971	Hunting, trapping, Game propagation	17%
	Less connected industries[‡‡‡]	
SIC 0213	*Livestock - Hogs*	*2%*
	Firms with only 3-digit industry code[§§§]	*0%*

The cluster 'agriculture and farming' encompasses 293 industries, shared to different extent by 1,769 firms. The core structure of the cluster comprises of 51 industry codes, exhibited on Map 1. Overall, this cluster is a net contributor to 3% of the regional employment, however with a very

---

[‡‡‡] *Less connected codes* are those industry codes that are below the threshold chosen for the cluster map (2%, 3% or 5% intensity of ties - depending on the size and density of the cluster), and do not appear on the cluster map that identifies the core industries. However, less connected codes have significant number of firms operating in the industry, and appear in Maps 32, 33 and 34. Less connected codes are listed at the end of the code description table with their corresponding percentage of firms valid for each cluster. **This note is valid for all subsequent cluster maps in this section of the report**.

[§§§] *3-digit industry codes* are also not represented on individual cluster maps as they are reported by firms as a single industry code, and therefore can not be connected to any other industry. However, in some clusters they represent significant industry groups and encompass multiple industry operations. A total percentage for all 3-digit industry codes and a breakdown for individual 3-digit industry codes is given at the end of each table. **This note is valid for all subsequent cluster maps in this section of the report**.

high mean (see Table 2.). This suggests that this cluster comprises of generally large and diversified firms. The high density of inter-industry relations within this cluster suggests that these are mature firms with a large portfolio of operations.

The cluster structure, exhibited on Map 1., shows one dominant component containing five distinctive and densely connected segments[****] and two satellite components. The first most distinctive segment contains 21 industries which encompass firms that specialise simultaneously in all sub-segments of 'agriculture and farming' – livestock, dairy farms, wheat, cotton, soybeans and other field crops. The second segment is composed of 10 industries related mainly to agricultural services. The third significant segment encompasses firms that specialise simultaneously in 8 different industries related to fruit trees and nuts. These three segments are connected by a hub of one industry, which plays a central role in all three segments. This is a generic code for general farms, primarily crop (SIC 0191) which is general enough to provide incentives to firms to describe their portfolio of operations with it. The two connected small segments in the periphery encompass: fish products (3 industries), and specialty animal products (2 industries).

One of the satellite component comprising 5 densely interconnected industries, stands quite isolated, and represents the poultry segment of the cluster. The second small satellite component comprises of two industries and represents veterinary services (SIC 0741, 0742).

In addition to its dense structure, the 'agriculture and farming' cluster is also significantly connected to three other clusters: 'food processing', 'wood products', and 'wholesale trade' (Map 34 and Table 3). The connection to 'food processing' is via wholesale trade of fresh fruit and vegetables (SIC 5148) and wholesale trade - farm-product raw materials (SIC 5159). The connection to the 'wood products' cluster is via forestry services (SIC 0811, 0831, 0851). This suggests that firms in these industries have multiple input/output markets in the region and can develop close association with both clusters that they connect. Firms operating in bridging industries indicated by a connectivity code link different value chains and can draw synergies from multiple value-added relations.

[****] A *component* is a distinctive group of interconnected industries that are clearly identifiable from the visual representation of the structure of each cluster. A *segment* is a smaller section of a component, which has distinctive features, but is still an interconnected part of the component. Each segment is automatically coloured by the UCINET software as having different relations from the rest of the industries in the core structure.

Map. 2. CLUSTER "FOOD PROCESSING, BEVERAGES & TOBACCO"
5% of ties between industry codes - based on more than 27 firms
1,369 firms
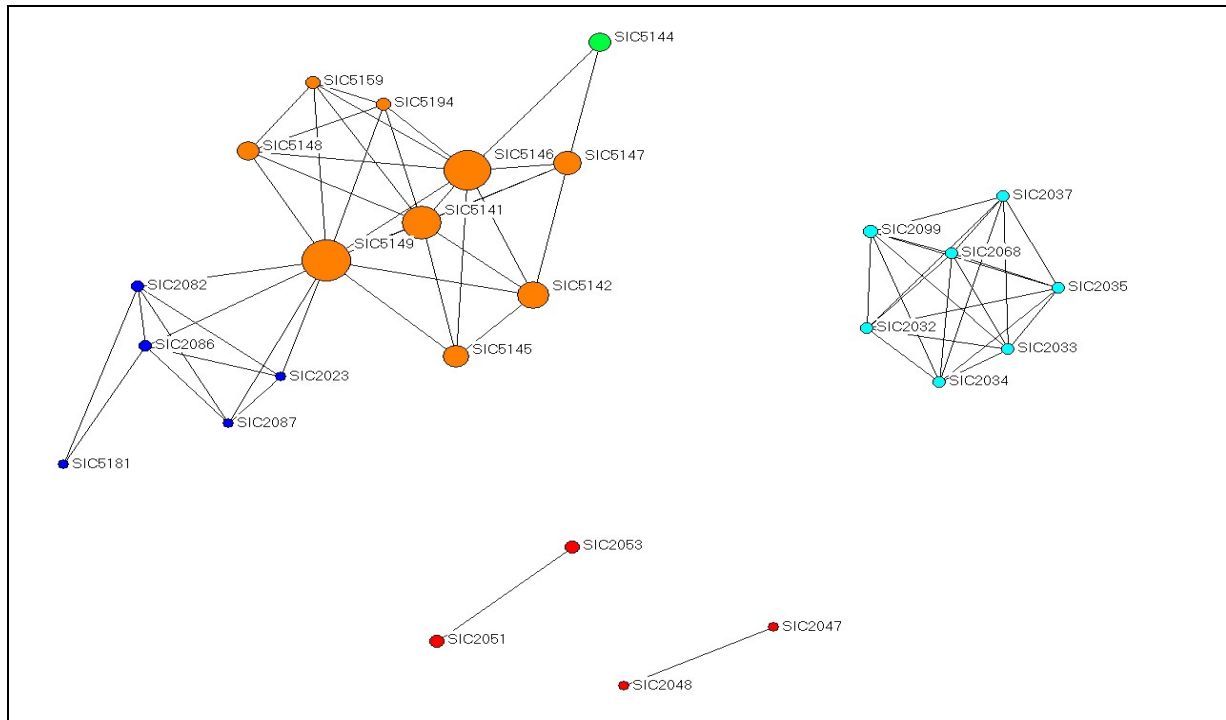
Code	Description	%
SIC2023	Dairy Products - Dry, condensed, evaporated products	2%
SIC2032	Food and Kindred Products - Preserved Fruits and Vegetables - Canned specialties	5%
SIC2033	Food and Kindred Products - Canned fruits and vegetables	5%
SIC2034	Food and Kindred Products - Dehydrated fruits, vegetables, soups	4%
SIC2035	Food and Kindred Products - Pickles, sauces, and salad dressings	5%
SIC2037	Food and Kindred Products - Frozen fruits and vegetables	4%
SIC2047	Grain Mill Products - Dog and cat food	2%
SIC2048	Grain Mill Products - Prepared feeds	2%
SIC2051	Food and Kindred Products - Bread, cake, and related products	7%
SIC2053	Food and Kindred Products - Frozen bakery products, except bread	7%
SIC2068	Food and Kindred Products - Salted & roasted nuts & seeds	4%
SIC2082	Food and Kindred Products - Beverages - Malt beverages	5%
SIC2086	Food and Kindred Products - Beverages - Bottled and canned soft drinks	4%
SIC2087	Beverages - Flavouring extracts and syrups	2%
SIC2099	Food preparations	7%
SIC5141	Wholesale Trade - Groceries, general line	37%
SIC5142	Wholesale Trade - Packaged frozen foods	28%
SIC5144	Wholesale Trade - Poultry and poultry products	16%
SIC5145	Wholesale Trade - Confectionery	21%
SIC5146	Wholesale Trade - Fish and sea-foods	48%
SIC5147	Wholesale Trade - Meats and meat products	24%
SIC5148	Wholesale Trade - Fresh fruits and vegetables	16%
SIC5149	Wholesale Trade - Groceries and related products	50%
SIC5159	Wholesale Trade - Farm-product raw materials	8%
SIC5181	Wholesale Trade - Beer and ale	2%
SIC5194	Wholesale Trade - Tobacco and tobacco products	7%
	Less connected industries	

37

SIC2013	*Food and Kindred Products - Sausages and other prepared meats*	*3%*
SIC5143	*Wholesale Trade - Dairy products, exc. dried or canned*	*2%*
SIC5182	*Wholesale Trade - Wine and distilled beverages*	*3%*
	Firms with only 3-digit industry code	*9%*
SIC201	*Food and Kindred Products - Meat Products*	*1%*
SIC202	*Food and Kindred Products - Dairy Products*	*0.5%*
SIC203	*Food and Kindred Products - Preserved Fruits and Vegetables*	*4%*
SIC204	*Food and Kindred Products - Grain Mill Products*	*0.5%*
SIC206	*Food and Kindred Products - Sugar and Confectionery Products*	*1%*
SIC208	*Food and Kindred Products - Beverages*	*1%*
SIC209	*Food and Kindred Products - Misc. Food and Kindred Products*	*1%*

The cluster 'food processing, beverages and tobacco' encompasses 157 industries, and 26 of them are represented in the core structure of the cluster. Nine percent of the firms in the cluster have declared only one 3-digit industry code and have not affected the position of the main cluster components represented on the Map above. The cluster is the third largest net-contributor to employment in the region (see Table 2.) representing 6% of the regional employment. It has 1,369 firms that have some of the largest revenue figures in the region.

The core structure of the cluster shows four components - two densely interconnected and two small and remote components. The largest component includes two segments connected by a bridge of wholesale trade of groceries, and related products and fish and seafood (SIC 5141, 5146, 5149). The two connected segments are: beverages (5 industries), and wholesale trade (10 industries), including the periphery segment of wholesale trade of poultry products (5144). The second component stands quite independently, and represents 7 interconnected industries that specialise in food preparation and food processing. The two components exhibit densely interconnected industries which suggest that firms in these industries have diversified similarly across a large part of the value chain. In addition, the structure of the cluster shows that there are two other small components that remain generally isolated from the rest of the cluster activities. One of them specialises in prepared animal food (SIC 2047, 2048), and the other specialises in bread making and related products (SIC 2051, 2053).

In addition, the cluster is connected to three other clusters: 'agriculture and farming' via wholesale and trade activities (SIC 5148), and directly to the 'retail' and 'wholesale and trade' clusters via meat and fish markets (SIC 5421), and via a whole range of wholesale of food products (see Map 34 and Table 3.). The domination of wholesale trade industry codes in this cluster suggests that much of the developments in this sector are driven by activities within the 'wholesale trade' cluster. This could be also an indication of ownership ties, where large wholesale trade firms control the downstream food production chain.

Map. 3. CLUSTER "CONSTRUCTION"
3% of ties between industry codes - based on more than 145 firms
14,676 firms
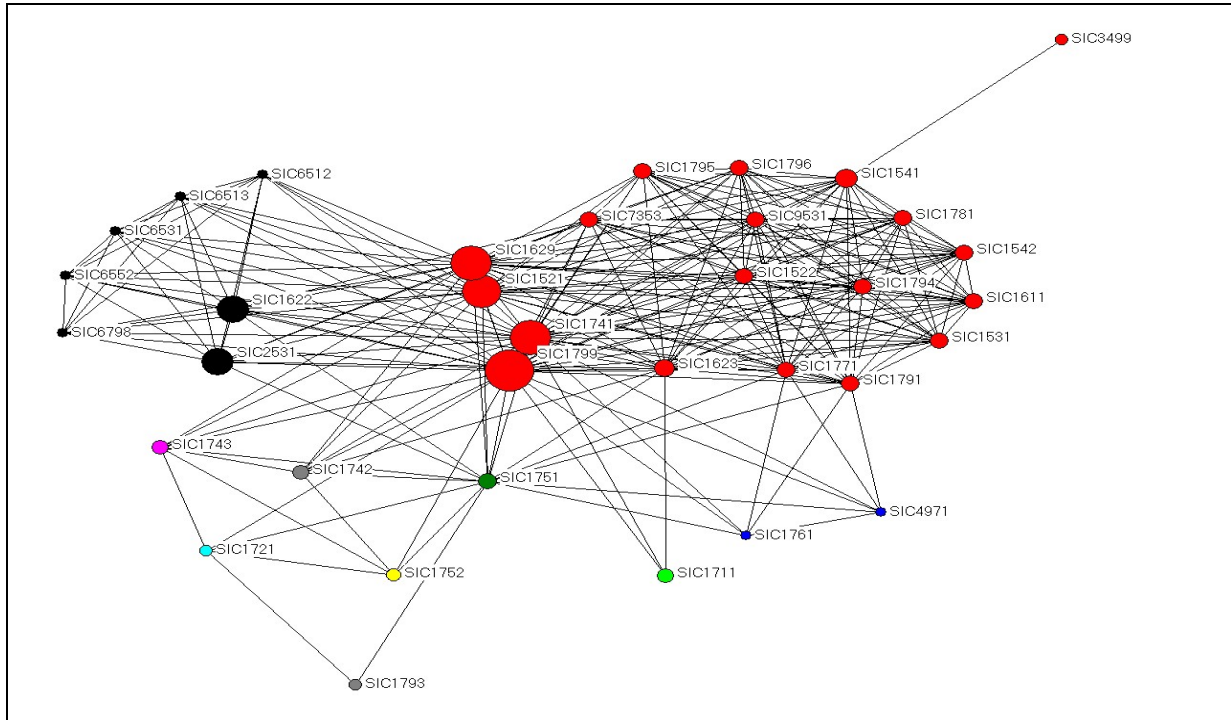
Code	Description	%
SIC1521	General Building Contractors - Residential - Single-family housing construction	56%
SIC1522	General Building Contractors - Residential construction	15%
SIC1531	General Building Contractors - Operative builders	15%
SIC1541	General Building Contractors –Non-residential- Industrial buildings and warehouses	22%
SIC1542	General Building Contractors – Non-residential construction	15%
SIC1611	Heavy Construction - Highway and street construction	15%
SIC1622	Heavy Construction - Bridge, tunnel and elevated highway	42%
SIC1623	Heavy Construction - Water, sewer, and utility lines	21%
SIC1629	Heavy construction	57%
SIC1711	Special Trade Contractors - Plumbing, heating, air-conditioning	11%
SIC1721	Special Trade Contractors - Painting and paper hanging	7%
SIC1731	Special Trade Contractors - Electrical work	9%
SIC1741	Special Trade Contractors - Masonry and other stone work	58%
SIC1742	Special Trade Contractors - Plastering, drywall, and insulation	11%
SIC1743	Special Trade Contractors - Terrazzo, tile, marble, mosaic work	11%
SIC1751	Special Trade Contractors - Carpentry work	15%
SIC1752	Special Trade Contractors - Floor laying and floor work	8%
SIC1761	Special Trade Contractors - Roofing, siding, and sheet metal work	2%
SIC1771	Special Trade Contractors - Concrete work	17%
SIC1781	Special Trade Contractors - Water well drilling	15%
SIC1791	Special Trade Contractors - Structural steel erection	17%
SIC1793	Special Trade Contractors - Glass and glazing work	4%
SIC1794	Special Trade Contractors - Excavation work	15%
SIC1795	Special Trade Contractors - Wrecking and demolition work	16%
SIC1796	Special Trade Contractors - Installing building equipment	15%
SIC1799	Special trade contractors	73%
SIC2531	Public building and related furniture	42%

39

SIC3499	Misc. Fabricated metal products	7%
SIC4971	Electric, Gas, and Sanitary Services - Irrigation systems	2%
SIC6512	Real Estate – Non-residential building operators	2%
SIC6513	Real Estate - Apartment building operators	2%
SIC6531	Real estate agents and managers	2%
SIC6552	Real Estate – Sub-dividers and developers	1%
SIC6798	Holding and Other Investment Offices - Real estate investment trusts	1%
SIC7353	Heavy construction equipment rental	15%
SIC9531	Housing programs	15%
	Firms with only 3-digit industry code	*0%*

The cluster 'construction' is among the top five clusters with the largest number of registered firms in the region. However, it has one of the smallest average number of employees per firm, which suggests that it is constituted of predominantly small and micro firms. It encompasses 375 industry codes and 36 of them are included in the core structure. This suggests that firms in this cluster declare a very broad portfolio of activities, and hence the inter-industry relations, captured in Map. 3., represent a very dense structure.

There are four dominant industries in this cluster that bridge the two main segments into a coherent component. These are: single family housing construction (SIC 1521); heavy construction (SIC 1629); masonry and other stone work (SIC 1741); and special trade contractors (SIC 1799). These are activities within the cluster that are performed by the largest number of firms and hold the entire structure of the cluster together. In addition, there are two distinctive segments and a number of other connected activities. Overall the largest segment on the right-hand side in the structure represents densely interconnected industries encompassing general building contractors, special trade contractors and heavy construction. The industry codes for housing programs (SIC 9531) and for residential construction (SIC 1522) and excavation work (1794) are in the heart of this industry agglomeration.

The other significant segment on the map (containing 7 industries) includes two industries related to the construction of public buildings and infrastructure, and a number of industries related to the real estate development. In the periphery to the main core of the construction cluster are situated a number of industries related to specialised trade contractors, such as roofing, electric, gas and sanitary services, floor work, plastering, painting and paper decoration, glass work.

The cluster is connected to the 'oil and gas' cluster via construction of utility lines (SIC1623). It is also connected to the 'industrial machinery and ICT' cluster via electrical work (SIC 1731) and fabricated metal products (SIC 3499), and the later is usually part of the machine building value

chain. The 'construction' cluster is also connected to the 'furniture' cluster (Map 34 and Table 3.). All connectivity industries demonstrate interconnected value chains, or market spaces where competition is determined by different forces deriving from different clusters.

Map. 4. CLUSTER "REAL ESTATE"
2% of ties between industry codes - based on more than 80 firms
18,897 firms
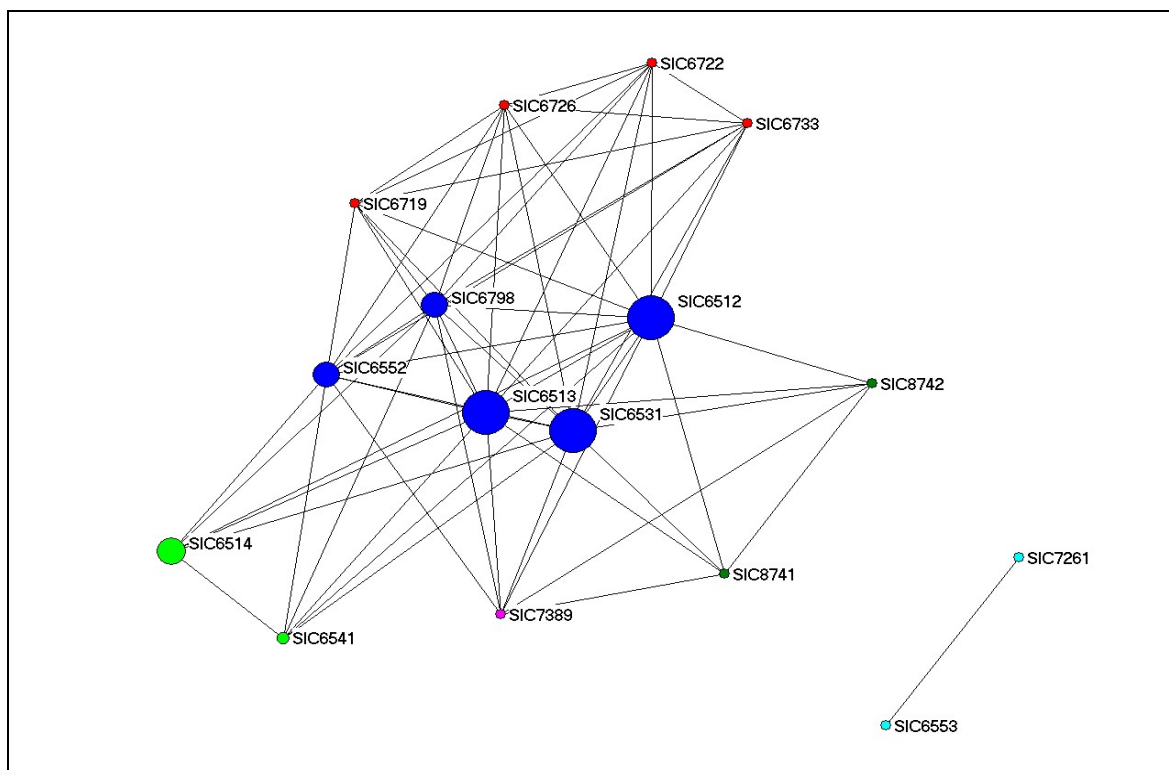
Code	Description	%
SIC6512	Real Estate – Non-residential building operators	87%
SIC6513	Real Estate - Apartment building operators	87%
SIC6514	Dwelling operators, exc. Apartments	45%
SIC6531	Real estate agents and managers	88%
SIC6541	Title abstract offices	7%
SIC6552	Real Estate – Sub-dividers and developers	38%
SIC6553	Cemetery sub-dividers and developers	0,5%
SIC6719	Holding companies	0,6%
SIC6722	Investment offices - Management investment, open-end	0,6%
SIC6726	Investment offices	0,6%
SIC6733	Trusts	0,6%
SIC6798	Holding and other investment offices - Real estate investment trusts	38%
SIC7261	Funeral service and crematories	0,5%
SIC7389	Business services	0,5%
SIC8741	Management services	0,4%
SIC8742	Management consulting services	0,4%
	Firms with only 3-digit industry code	*12%*
SIC651	*Real Estate Operators and Lessors*	*12%*

The cluster 'real estate' has one of the largest numbers of registered firms and one of the smallest average revenue per firm and employment per firm. It comprises of 10% of the firms in the region and only 1% of the total revenue and 1% of the total regional employment. We were able to identify the core structure of the cluster at the level of the top 2% of the most significant inter-industry ties.

Even this high threshold includes industries with very marginal impact on the cluster activities with less than 1% of the firms in the cluster.

The cluster comprises of 275 industries, and 14 of these can be qualified as core industries that are densely interconnected into one distinctive component. There is one additional small component on the periphery of the cluster, comprising of two industries related to cemetery sub-dividers and funeral services (SIC 6553 and 7261), which means that there are some synergies between the funeral services and the real estate business.

The most dominant industries in the cluster are non-residential building operators (SIC 6512), apartment building operators (SIC 6513) and real estate agents (SIC 6531), all of which are performed by 87-88% of the firms in the cluster. Clearly the rest of the cluster activities are supplementary business activities performed by selected real estate firms.

The 'real estate' cluster is not significantly connected to any other cluster which confirms that it is serving primarily the local market. However, the profile of the 16 core industries shows a wide diversification into business, management and investment services.

Map. 5. CLUSTER "FURNITURE, FIXTURE & WOOD PRODUCTS"

5% of ties between industry codes - based on more than 127 firms
1,254 firms
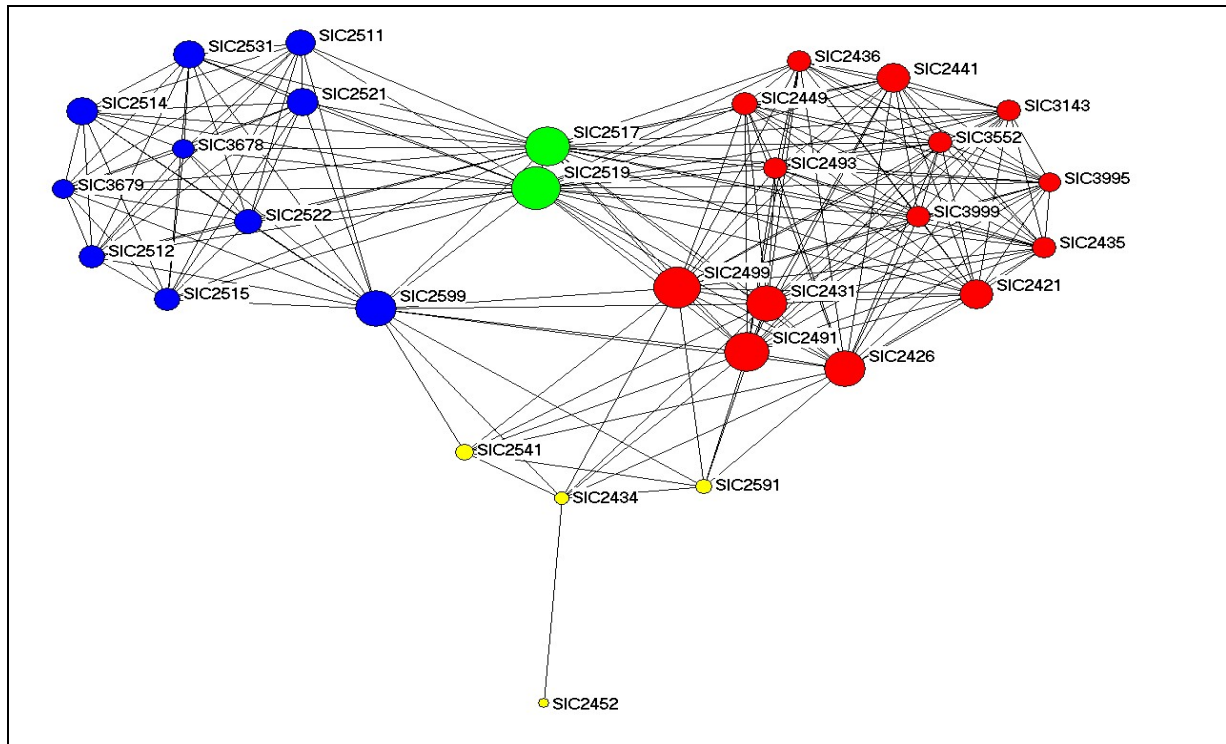
Code	Description	%
SIC2421	Lumber and Wood Products - Sawmills and planning mills, general	28%
SIC2426	Lumber and Wood Products - Hardwood dimension and flooring mills	34%
SIC2431	Lumber and Wood Products - Millwork	33%
SIC2434	Lumber and Wood Products - Wood kitchen cabinets	14%
SIC2435	Lumber and Wood Products - Hardwood veneer and plywood	21%
SIC2436	Lumber and Wood Products - Softwood veneer and plywood	21%
SIC2441	Nailed wood boxes and shook	28%
SIC2449	Wood containers	22%
SIC2452	Prefabricated wood buildings	10%
SIC2491	Miscellaneous Wood Products - Wood preserving	36%
SIC2493	Reconstituted wood products	21%
SIC2499	Miscellaneous Wood Products	38%
SIC2511	Wood household furniture	25%
SIC2512	Upholstered household furniture	23%
SIC2514	Metal household furniture	27%
SIC2515	Mattresses and bedsprings	21%
SIC2517	Wood TV and radio cabinets	37%
SIC2519	Household furniture	40%
SIC2521	Wood office furniture	27%
SIC2522	Office furniture, except wood	23%
SIC2531	Public building and related furniture	26%
SIC2541	Wood partitions and fixtures	16%
SIC2591	Miscellaneous Furniture and Fixtures - Drapery hardware, blinds and shades	15%
SIC2599	Furniture and fixtures	33%
SIC3143	Leather and Leather Products - Men's footwear, except athletic	20%
SIC3552	Special Industry Machinery - Textile machinery	20%

44

SIC3678	Electronic Components and Accessories - Electronic connectors	19%
SIC3679	Electronic components	19%
SIC3995	Burial caskets	20%
SIC3999	Manufacturing industries	20%
	Less connected industries	
SIC0811	*Forestry - Timber tracts*	*7%*
SIC0831	*Forest products*	*7%*
SIC0851	*Forestry services*	*7%*
SIC2411	*Lumber and Wood Products - Logging*	*14%*
SIC2429	*Special product sawmills*	*7%*
SIC2439	*Structural wood members*	*10%*
SIC2448	*Wood pallets and skids*	*2%*
SIC2451	*Wood Buildings - Mobile homes*	*10%*
SIC2542	*Prefabricated wood buildings*	*5%*
SIC5021	*Wholesale Trade - Furniture*	*4%*
SIC5031	*Wholesale Trade - Lumber, plywood, and millwork*	*21%*
	Firms with only 3-digit industry code	*0%*

The cluster 'furniture, fixture and wood products' is composed of 1,254 firms that have insignificant impact on the regional employment and revenue (see Table 2.). The cluster comprises of 217 industries, and 30 of these are interconnected in the core structure. At the same time, there are 11 other industries with significant number of firms that remain much less connected. This suggests that the cluster contains a significant number of specialised firms that operate in related industries, but that do not diversify much across the main cluster value chain.

The core structure of the cluster is composed of three interconnected segments. Two of these segments are very large and are connected via a bridge of two industries - wood TV and radio cabinets (SIC 2517) and household furniture (SIC 2519), which have attracted between 37-40% of the firms in this cluster. The large segment on the right-hand side comprises of industries related to wood products, while the other large segment on the left contains industries related to furniture. The third small segment contains three industries and represents supplementary industries such as wood partitions, wooden homes or wooden blinds and shades that connect mainly to wood products, or to the generic code for furniture and fixture (SIC 2599).

The cluster as a whole is connected to four other clusters: 'agriculture and farming' (via the forestry industries), 'construction' (via public buildings and furniture), 'industrial machinery and ICT' (via electronic components), 'miscellaneous products' (via leather products), and to 'wholesale trade' (via trade of lumber and plywood) (see Table 3.).

Map. 6. CLUSTER "MISCELLENEOUS CONSUMER PRODUCTS"
3% of ties between industry codes - based on more than 36 firms
2,042 firms
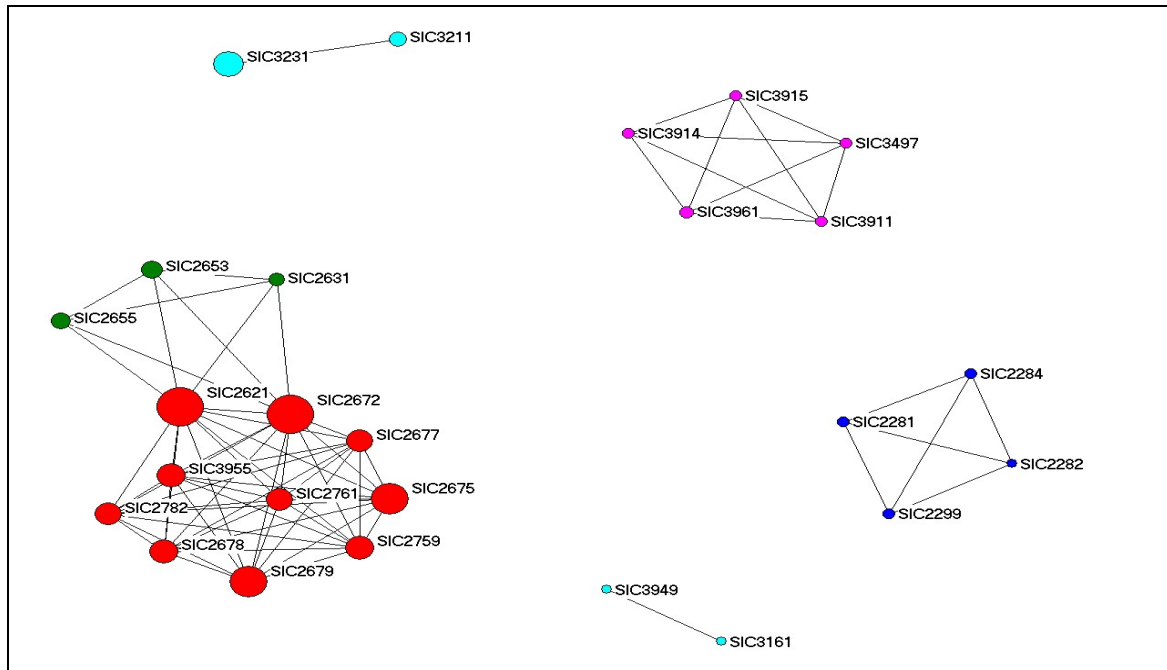
Code	Description	%
SIC2281	Textile Mill Products - Yarn spinning mills	2%
SIC2282	Textile Mill Products - Throwing and winding mills	2%
SIC2284	Textile Mill Products - Thread mills	2%
SIC2299	Textile Mill Products - Textile goods	2%
SIC2621	Paper and Allied Products - Paper mills	8%
SIC2631	Paper and Allied Products - Paperboard mills	3%
SIC2653	Paper and Allied Products - Corrugated and solid fiber boxes	4%
SIC2655	Paper and Allied Products - Fiber cans, drums and similar products	4%
SIC2672	Paper and Allied Products - Paper coated and laminated	8%
SIC2675	Paper and Allied Products - Die-cut paper and board	7%
SIC2677	Paper and Allied Products - Envelopes	5%
SIC2678	Paper and Allied Products - Stationery products	5%
SIC2679	Paper and Allied Products - Converted paper products	7%
SIC2759	Printing and Publishing - Commercial printing	5%
SIC2761	Printing and Publishing - Manifold business forms	5%
SIC2782	Printing and Publishing – Blank books and loose-leaf binders	5%
SIC3161	Leather and Leather Products - Luggage	2%
SIC3211	Stone, Clay, and Glass Products - Flat glass	3%
SIC3231	Stone, Clay, and Glass Products - Products of purchased glass	5%
SIC3497	Fabricated Metal Products - Metal foil and leaf	2%
SIC3911	Miscellaneous Manufacturing Industries - Jewellery, precious metal	2%
SIC3914	Miscellaneous Manufacturing Industries - Silverware and plated ware	2%
SIC3915	Miscellaneous Manufacturing Industries - Jewellers' materials and lapidary work	2%
SIC3949	Miscellaneous Manufacturing Industries - Sporting and athletic goods	2%
SIC3955	Miscellaneous Manufacturing Industries - Carbon paper and inked ribbons	5%
SIC3961	Miscellaneous Manufacturing Industries - Costume jewellery	2%
	Less connected industries	
SIC1411	*Non-metallic Minerals - Dimension stone*	*1%*

SIC1429	*Non-metallic Minerals - Crushed and broken stone*	*2%*
SIC1442	*Construction sand and gravel*	*1%*
SIC1446	*Industrial sand*	*1%*
SIC1474	*Chemical and Fertilizer Minerals - Potash, soda, and borate minerals*	*1%*
SIC1479	*Chemical and fertilizer mining*	*1%*
SIC1499	*Miscellaneous non-metallic minerals*	*1%*
SIC2339	*Women's and misses' outerwear*	*1%*
SIC2369	*Girls' and children's outerwear*	*1%*
SIC3111	*Leather tanning and finishing*	*2%*
SIC3221	*Glass containers*	*1%*
SIC3229	*Pressed and blown glass*	*1%*
SIC3251	*Brick and structural clay tile*	*1%*
SIC3253	*Ceramic wall and floor tile*	*1%*
SIC3259	*Structural clay products*	*1%*
SIC3269	*Pottery products*	*2%*
SIC3271	*Concrete block and brick*	*1%*
SIC3272	*Concrete products*	*1%*
SIC3291	*Abrasive products*	*2%*
SIC3851	*Ophthalmic goods*	*1%*
	Firms with only 3-digit industry code	*59%*
SIC225	*Textile Mill Products - Knitting Mills*	*1%*
SIC232	*Apparel and Other Textile Products - Men's and Boys' Furnishings*	*4%*
SIC238	*Miscellaneous Apparel and Accessories*	*2%*
SIC239	*Misc. Fabricated Textile Products*	*1%*
SIC329	*Misc. Non-metallic Mineral Products*	*1%*
SIC394	*Toys and Sporting Goods*	*3%*
SIC395	*Pens, Pencils, Office, and Art Supplies*	*47%*

This cluster is an agglomeration of 2,042 firms that operate in 295 industries. The cluster contributes to 2% of the employment in the region and the average employment per firm in this cluster (mean 216) is similar to the average employment per firm for the region (mean 238). In spite of the significant number of firms in the cluster, 59% of them are focused and report only one 3-digit industry code. Although the title of this cluster suggests very fragmented agglomeration of firms, industries are interconnected and the map shows clearly one large component consisting of two connected segments, and four additional disconnected components.

The largest interconnected component is the dominant for the cluster and contains two segments – one of which represents mainly paper products and some publishing, while the second component represents the packaging sector – fibre boxes, fibre cans, and their input – paperboard mills. The four disconnected components represent almost individual small clusters, such as: stone, clay and glass products (two core industries), miscellaneous metal products including jewellery and silverware (five core industries), textile products (four core industries), and leather and sporting goods (two core industries). The large number of unconnected codes that are significant to the cluster also demonstrates the generic fragmentation of this agglomeration and the fact that firms

operating in different segments, connect to value chains in different clusters. The cluster is hugely interconnected with other clusters, such as: 'chemicals', 'metal products', 'instrumentation', 'motor trade', 'furniture, fixture and wood products', and 'publishing', which suggests that the developments in it will be determined at large by processes in the other connected clusters. In future clustering attempts, it might be more appropriate to allocate these firms to clusters and value chains that correspond with the main final product.

Map. 7. CLUSTER "UTILITIES"
20% of ties between industry codes - based on more than 16 firms
305 firms
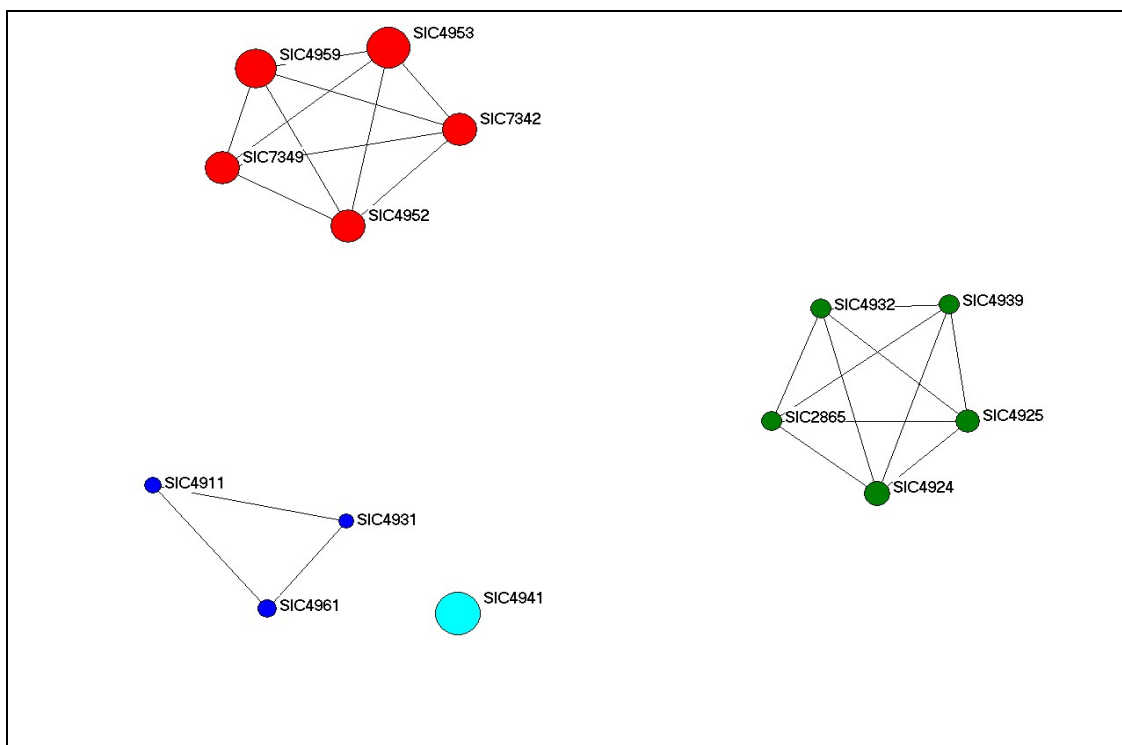
Code	Description	%
SIC2865	Industrial Organic Chemicals - Cyclic crudes and intermediates	8%
SIC4911	Electric services	7%
SIC4924	Natural gas distribution	12%
SIC4925	Gas production and/or distribution	10%
SIC4931	Electric and other services combined	6%
SIC4932	Gas and other services combined	8%
SIC4939	Combination utilities	8%
SIC4941	Water supply	24%
SIC4952	Sewerage systems	17%
SIC4953	Refuse systems	23%
SIC4959	Sanitary services	21%
SIC4961	Steam and air-conditioning supply	7%
SIC7342	Disinfecting & pest control services	18%
SIC7349	Building maintenance services	17%
	Less connected industries	
SIC4499	*Water Transportation - Water transportation services*	*4%*
	Firms with only 3-digit industry code	*27%*
SIC491	*Electric Services*	*27%*

The 'utilities' cluster is a small cluster, with a small number of firms in it (only 305 firms), but with very high contribution to the regional revenue – the third highest total cluster revenue in the region, and with the highest average revenue per firm (see Table 2.). Due to the small number of firms, it has also the second highest cluster average employment per firm in the region, which confirms that

it comprises of predominantly large firms. It encompasses 37 industries, and 14 of these are in the core structure of the cluster.

The core structure of the cluster shows four distinctive components, responsible separately for gas (5 industries), electricity (3 industries), refuse system (5 industries), and water – one single 4-digit code encompassing 24% of the firms in the cluster. The water supply system appears to be the most disconnected part of the cluster, where firms do not appear to have diversified into other support services. An interesting part of the cluster are 27% of the firms that have declared only one 3-digit code for electric services (SIC 491) and do not appear on the map.

Through its main components, the cluster is highly connected to five other clusters in the region: 'chemicals' (via industrial organic chemicals - cyclic crudes and intermediates); 'marine technologies' (via water transportation services); 'miscellaneous products' (via glass and prime-metal manufacturing), and 'business services' (via building maintenance services) (see Table 3.). The strong internal segmentation of this cluster and separation between different types of utility operations is an indicator of very different processes taking place in each of the components. The high revenue and employment per firm is also an indicator of high concentration of operations within individual firms and within the components themselves.

Map. 8. CLUSTER "COMMUNICATION SERVICES"
3% of ties between industry codes - based on more than 37 firms
1,540 firms
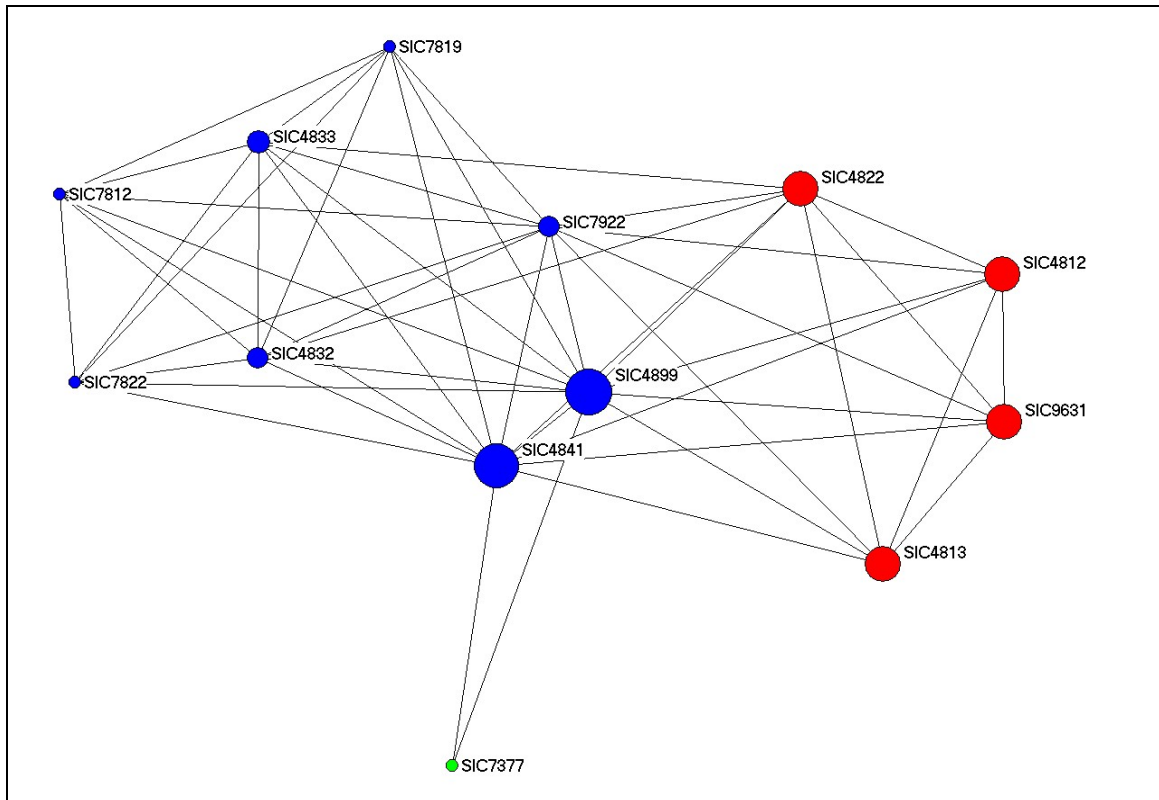
Code	Description	%
SIC4812	Radiotelephone communications	63%
SIC4813	Telephone communications, exc. Radio	63%
SIC4822	Telegraph and other communications	63%
SIC4832	Radio broadcasting stations	28%
SIC4833	Television broadcasting stations	30%
SIC4841	Cable and other pay TV services	89%
SIC4899	Communication services	92%
SIC7377	Computer rental and leasing	2%
SIC7812	Motion picture and video production	3%
SIC7819	Services allied to motion pictures	3%
SIC7822	Motion picture and tape distribution	3%
SIC7922	Theatrical producers and services	26%
SIC9631	Regulation and administration of utilities	62%
	Less connected industries	
SIC4311	*Postal services*	*4%*
	Firms with only 3-digit industry code	*0%*

This cluster comprises of 1,540 firms that contribute approximately 2% of the regional employment and 2% of the regional revenue. It involves 142 industries, and only 13 of these are represented in the core of the cluster structure on Map.8. above. The core structure of the cluster exhibits one coherent core component with highly interconnected industries. Two of these industries are very central to the developments in this cluster and they are: cable and other pay TV services (SIC 4841 -

51

reported by 89% of the firms) and generic communication services (SIC 4899 - reported by 92% of the firms).

The core structure of the cluster identifies two separate segments or areas of development. One of the segments includes 4 industries reflecting the main communications – telephone, radiotelephone, telegraph, and the regulation and administration of communications. The other segment includes 8 industries in the field of content services and other related services to communications, such as motion picture and video production, theatrical production, and radio broadcasting stations. There is an additional small segment that has been incorporated into this cluster such as computer rental and leasing (SIC 7377), which is related to the receiving of cable and other pay TV services.

The cluster of 'communication services' is interconnected with another cluster – 'amusement and recreation' - via four industry codes related to services supporting motion picture and theatrical production (see Table 3.). This connectivity perhaps is the main driving force that pools some of the industries (on the left-hand side) away from the communication infrastructure.

Map. 9. CLUSTER "MISCELLENEOUS SERVICES"
3% of ties between industry codes - based on more than 145 firms
30,850 firms
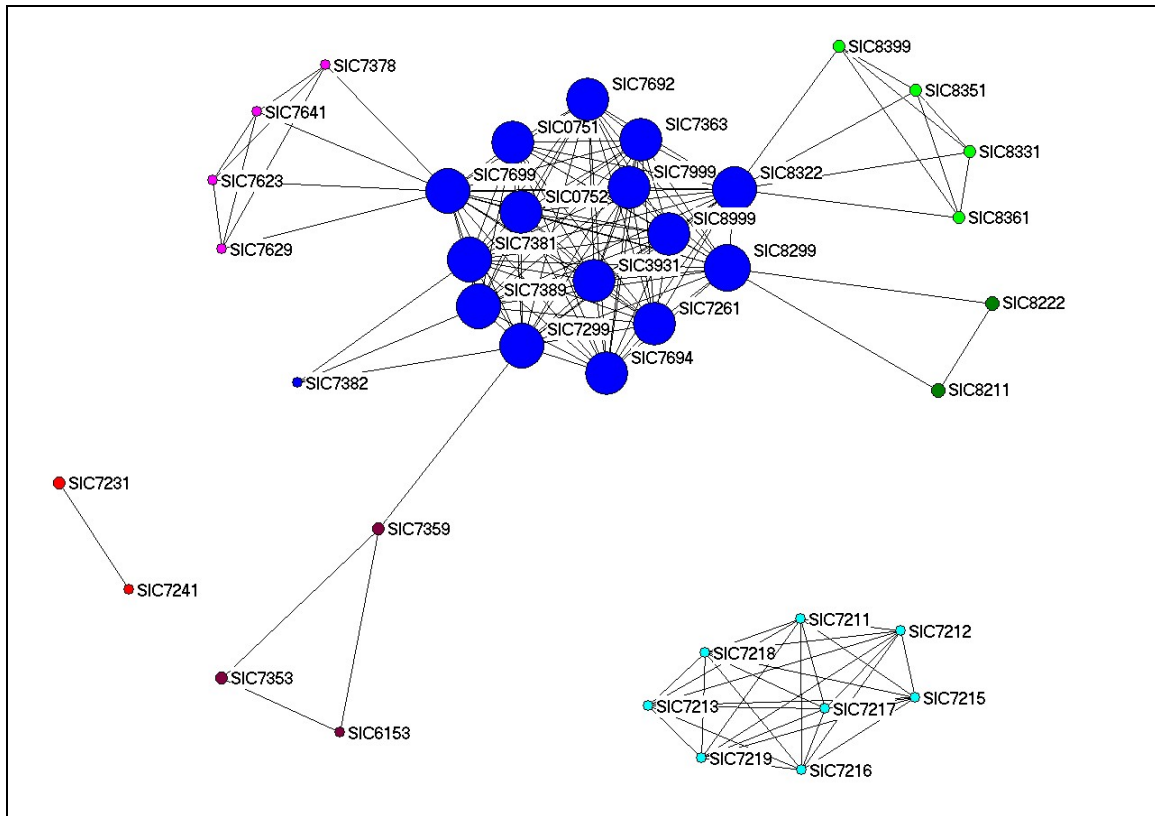
Code	Description	%
SIC0751	Animal Services, Except Veterinary - Livestock services, exc. Veterinary	28%
SIC0752	Animal specialty services	28%
SIC3931	Miscellaneous Manufacturing Industries - Musical instruments	28%
SIC6153	Short-term business credit	0,5%
SIC7211	Personal Services - Power laundries, family and commercial	0,5%
SIC7212	Personal Services - Garment pressing and cleaners' agents	0,5%
SIC7213	Personal Services - Linen supply	0,5%
SIC7215	Personal Services - Coin-operated laundries and cleaning	0,5%
SIC7216	Personal Services – Dry-cleaning plants, except rug	0,5%
SIC7217	Personal Services - Carpet and upholstery cleaning	0,5%
SIC7218	Personal Services - Industrial launderers	0,5%
SIC7219	Personal Services - Laundry and garment services	0,5%
SIC7231	Beauty shops	1%
SIC7241	Barber shops	1%
SIC7261	Funeral service and crematories	28%
SIC7299	Miscellaneous personal services	30%
SIC7353	Business Services - Heavy construction equipment rental	2%
SIC7359	Business Services - Equipment rental and leasing	2%
SIC7363	Business Services - Help supply services	28%
SIC7378	Business Services - Computer maintenance and repair	1%
SIC7381	Detective and armoured car services	29%
SIC7382	Security systems services	1%
SIC7389	Business services	29%
SIC7623	Refrigeration service and repair	1%

SIC7629	Electrical repair shops	1%
SIC7641	Re-upholstery and furniture repair	1%
SIC7692	Welding repair	28%
SIC7694	Armature rewinding shops	28%
SIC7699	Repair services	29%
SIC7999	Amusement and recreation	28%
SIC8211	Elementary and secondary schools	3%
SIC8222	Educational Services - Junior colleges	3%
SIC8299	Schools and educational services	31%
SIC8322	Social Services - Individual and family services	30%
SIC8331	Social Services - Job training and related services	2%
SIC8351	Social Services - Child day care services	2%
SIC8361	Residential care	2%
SIC8399	Social services	2%
SIC8999	Services	29%
	Firms with only 3-digit industry code	*60%*
SIC738	*Miscellaneous Business Services*	*58%*

The cluster 'miscellaneous services' is the second largest cluster in the region with 30,850 firms. However, both its average employment and revenue per firm are below the average for the region (see Table 2.). It comprises of 335 industries and was created as an agglomeration of multiple services not else included. It is surprising that the cluster has a very strong interconnected core which represents at least a third of the total population of firms (or approximately 10,000 firms), and interconnects almost all specific service areas.

The core structure of the cluster contains 39 industries which are organised in three distinctive components, one of which is central for the cluster. The largest and most central segment of the central component is a multi-diversified agglomeration of 15 industries that encompass all possible areas (miscellaneous personal services, veterinary services, funeral services, business services, detective and armed car service, schools, repair services, security services, family services. There are five additional segments connected to this main segments: education (2 industries), social services (4 industries), repair services (4 industries), security systems (1 industry), and rental and short-term credit services (3 industries). In addition, there are two separate components – one dyad representing beauty and barber shops, and a densely interconnected 8 industries for personal services. Another distinctive feature of this cluster is that 58% of the firms have declared only one industry code and this is the 3-digit generic code for miscellaneous business services (SIC 738), which is not represented in the structure of the core, but obviously is the most dominant group of firms. The structure of the cluster shows that there are synergies for diversifying across the entire space of miscellaneous services, as contrary to the findings of the cluster 'miscellaneous products'.

In addition, the cluster is highly interconnected to other clusters via a number of industry-bridges and connectivity codes. Among the connected clusters are: 'computer services', 'publishing', 'retail', 'hotels and catering', 'recreation services', 'health services', and the 'multi-diversified' cluster. This broad connectivity suggests that outside of the integrated core of the cluster, there are multiple scattered industries that do not form an integrated value chain, but participate in the value chains of other clusters. The integrated and interconnected core itself represents synergies in delivering distinctive services without particular roots to value chains.

Map. 10. CLUSTER "HEALTH SERVICES"

3% of ties between industry codes - based on more than 32 firms

1,473 firms
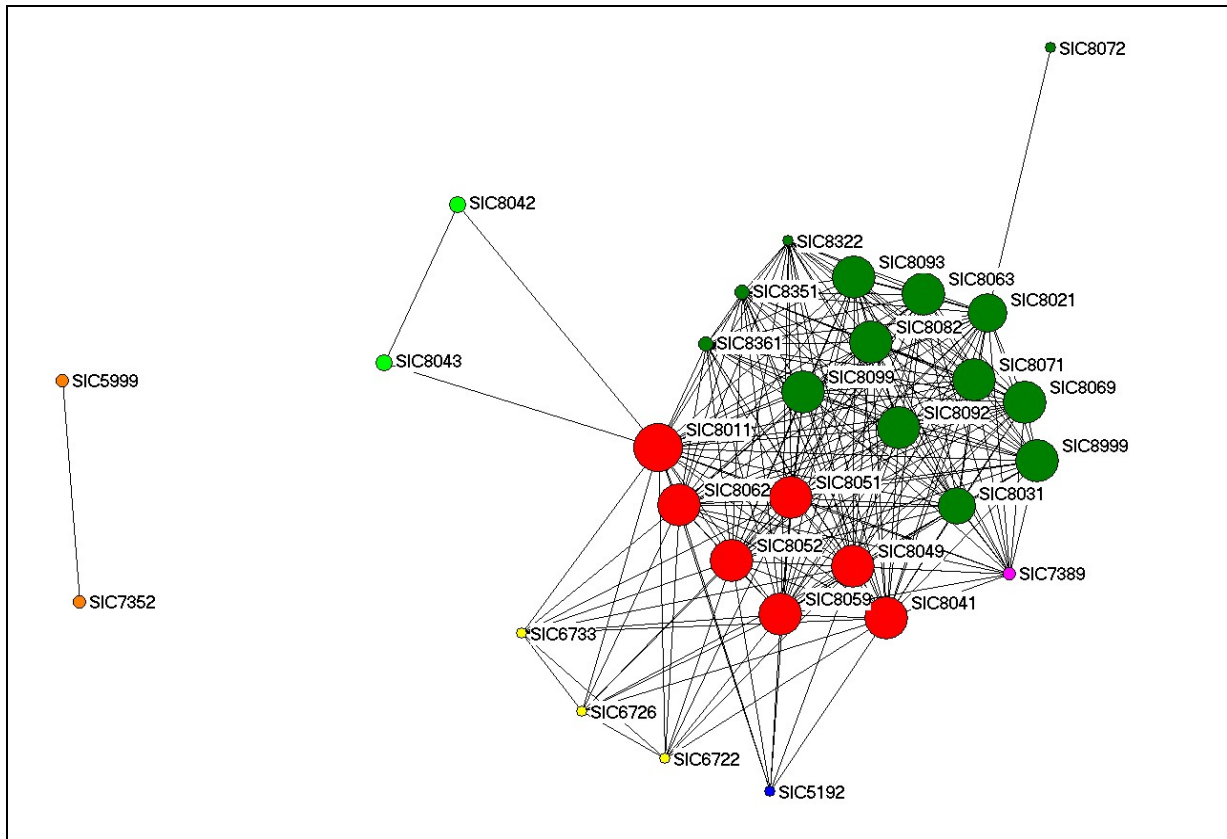
Code	Description	%
SIC5192	Wholesale Trade - Books, periodicals, and newspapers	2%
SIC5999	Miscellaneous retail stores	6%
SIC6722	Investment Offices - Management investment, open-end	2%
SIC6726	Investment offices	2%
SIC6733	Trusts	2%
SIC7352	Business Services - Medical equipment rental	5%
SIC7389	Business services	5%
SIC8011	Health Services - Offices and clinics of medical doctors	92%
SIC8021	Health Services - Offices and clinics of dentists	69%
SIC8031	Health Services - Offices of osteopathic physicians	66%
SIC8041	Health Services - Offices and clinics of chiropractors	77%
SIC8042	Health Services - Offices and clinics of optometrists	16%
SIC8043	Health Services - Offices and clinics of podiatrists	16%
SIC8049	Health Services - Offices of health practitioners	77%
SIC8051	Health Services - Skilled nursing care facilities	77%
SIC8052	Health Services - Intermediate care facilities	77%
SIC8059	Health Services - Nursing and personal care	77%
SIC8062	General medical and surgical hospitals	77%
SIC8063	Psychiatric hospitals	77%
SIC8069	Specialty hospitals exc. Psychiatric	77%
SIC8071	Medical laboratories	77%
SIC8072	Dental laboratories	3%
SIC8082	Home health care services	77%

56

SIC8092	Kidney dialysis centres	77%
SIC8093	Specialty outpatient clinics	77%
SIC8099	Health and allied services	77%
SIC8322	Social Services - Individual and family services	3%
SIC8351	Social Services - Child day care services	12%
SIC8361	Residential care	12%
SIC8999	Services	77%
	Firms with only 3-digit industry code	*0%*

The 'health services' cluster comprises of 1,473 firms that have minimal revenue per firm, and well above the regional average employment per firm (11%). It encompasses 277 industries and 30 of these constitute the core structure of the cluster. The core structure of the cluster has one large and very well connected component and four small segments connected to it. The large component is densely connected and contains firms, which appear to be diversified across the entire range of business activities in the health services. An interesting observation is that in spite of the dense connectivity in the core, two distinctive areas can be described – one containing 7 industries that operate general health services offices and clinics, and the other containing 11 industries that specialise in health services and clinics such as psychiatric, osteopathic, dentistry, specialty outpatient clinics, and medical laboratories. The dental laboratories are a small segment in the periphery (SIC 8072). Optometric clinics and podiatrists are another small segment (SIC 8042, 8043), along with another small triad segment that contains primarily investment activities industries (SIC 6733, 6726, 6722). The small dyadic disconnected component in the periphery contains rental of medical equipment and miscellaneous retail stores, and as such stretching into business services (SIC 7352, 5999).

The 'health services' cluster is connected to a number of other clusters in the region, among which: 'instrumentation', 'retail', 'hotel and catering', and the 'multi-diversified' cluster. These links can not be explained clearly, as they obviously contain activities that are quite peripheral to the health cluster.

Map. 11. CLUSTER "PHARMACEUTICALS"
5% of ties between industry codes - based on more than 6 firms
285 firms
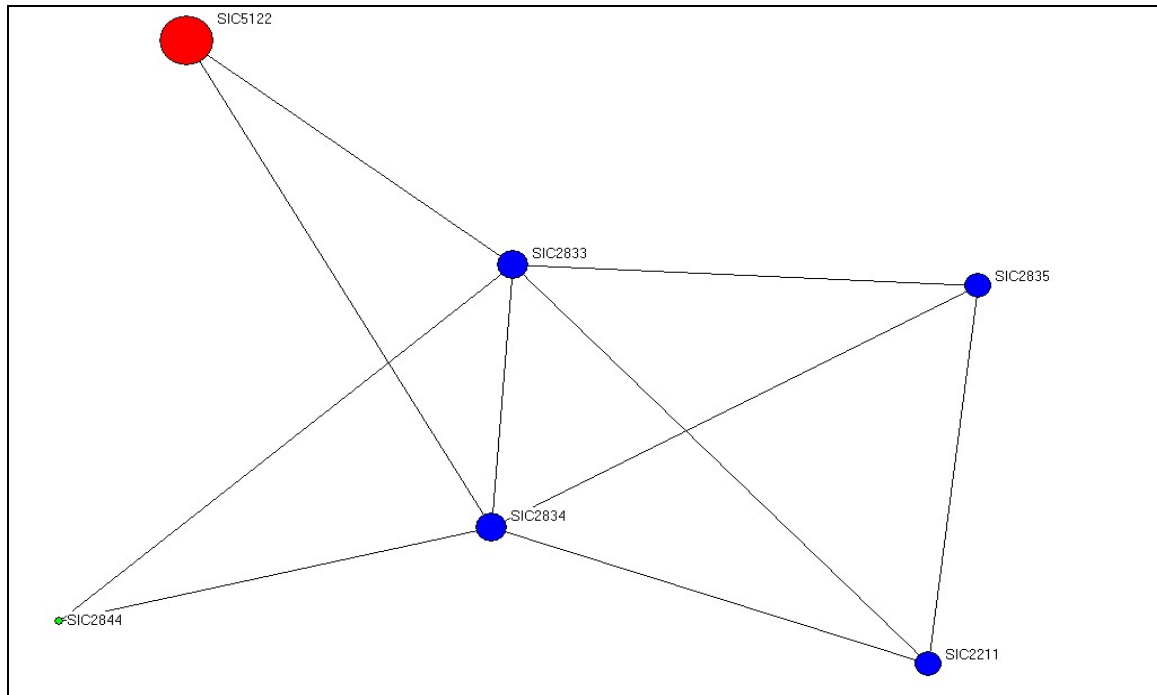
Code	Description	%
SIC2211	Textile Mill Products – Broad-woven fabric mills, cotton	30%
SIC2833	Drugs - Medicinals and botanicals	35%
SIC2834	Drugs - Pharmaceutical preparations	36%
SIC2835	Drugs - Diagnostic substances	30%
SIC2844	Toilet preparations	2%
SIC5122	Wholesale Trade - Drugs, proprietaries, and sundries	68%
	Firms with only 3-digit industry code	*0%*

This is a small cluster with only 285 firms. These firms have very high average revenue and employment per firm (see Table 2.). A few large firms frame the core structure of the cluster and determine the inter-industry linkages. The cluster encompasses 40 industries, and only 6 of them are interconnected by firms diversifying simultaneously in them. The structure of the cluster is composed of one single component, comprising of the 4 core industries related to drugs manufacturing and cotton and textile products, and two additional industries that are bridges to the chemical industry (toilet preparations – SIC 2844) and to the wholesale and trade sector – selling drugs and sundries (SIC 5122). Two-third of the firms in this cluster are engaged in wholesale and retail – as a source of revenue. The dynamics of the cluster is dominated by these core firms that determine the core component, and by operations in the wholesale trade area of activities. The 'pharmaceuticals' is connected to the 'chemicals and allied products cluster via shared activities in drugs, toilet preparation, soap and detergents industries.

Map. 12. CLUSTER "CHEMICALS & ALLIED PRODUCTS"

5% of ties between industry codes - based on more than 54 firms
1,116 firms
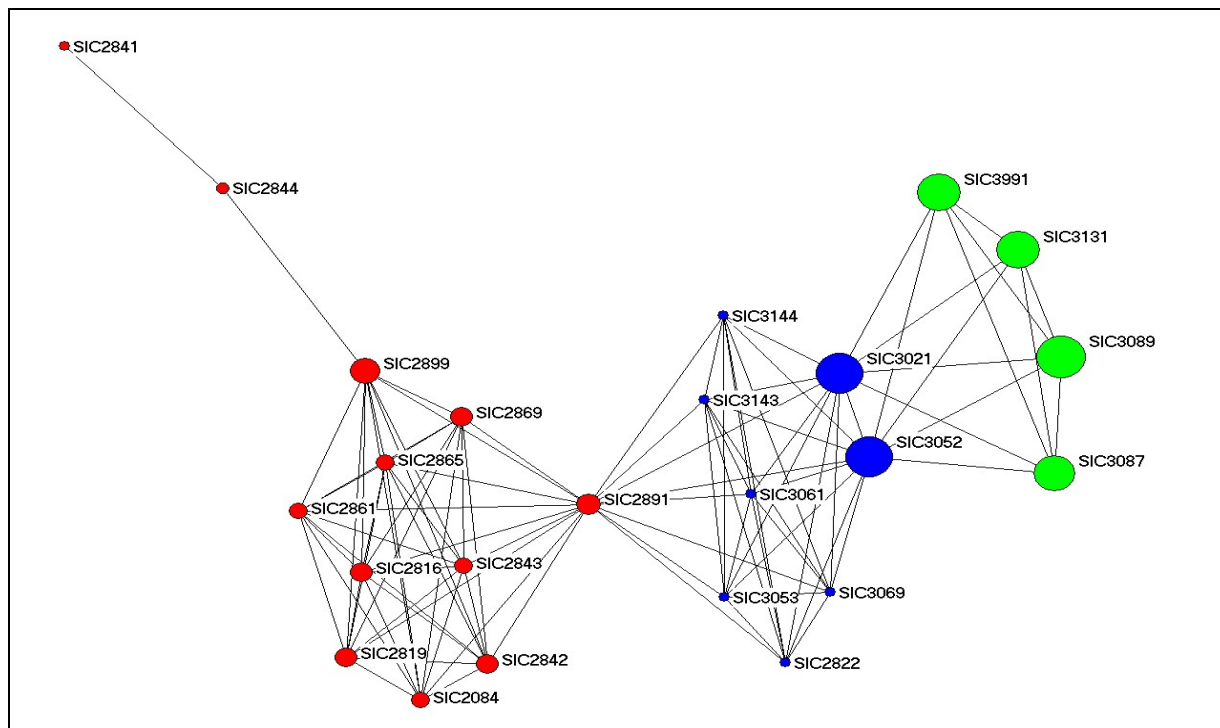
Code	Description	%
SIC2084	Beverages - Wines, brandy, and brandy spirits	12%
SIC2816	Industrial Inorganic Chemicals - Inorganic pigments	18%
SIC2819	Industrial Inorganic Chemicals - Industrial inorganic chemicals	18%
SIC2822	Plastics Materials and Synthetics - Synthetic rubber	6%
SIC2841	Soap and other detergents	5%
SIC2842	Soap, Cleaners, and Toilet Goods - Polishes and sanitation goods	18%
SIC2843	Soap, Cleaners, and Toilet Goods - Surface active agents	12%
SIC2844	Soap, Cleaners, and Toilet Goods - Toilet preparations	7%
SIC2861	Gum and wood chemicals	13%
SIC2865	Cyclic crudes and intermediates	14%
SIC2869	Industrial organic chemicals	18%
SIC2891	Miscellaneous Chemical Products - Adhesives and sealants	19%
SIC2899	Miscellaneous Chemical Products - Chemical preparations	25%
SIC3021	Rubber and plastics footwear	44%
SIC3052	Rubber and plastics hose and belting	44%
SIC3053	Rubber and Plastics Footwear - Gaskets, packing and sealing devices	5%
SIC3061	Fabricated Rubber Products - Mechanical rubber goods	5%
SIC3069	Fabricated Rubber Products - Fabricated rubber products	6%
SIC3087	Miscellaneous Plastics Products - Custom compound purchased resins	38%
SIC3089	Miscellaneous Plastics Products	46%
SIC3131	Leather and Leather Products - Footwear cut stock	39%
SIC3143	Leather and Leather Products - Men's footwear, except athletic	5%
SIC3144	Leather and Leather Products - Women's footwear, except athletic	5%
SIC3991	Miscellaneous Manufacturing Industries - Brooms and brushes	40%
	Less connected industries	

59

SIC	Description	%
SIC2671	*Paper coated and laminated, packaging*	*4%*
SIC2673	*Bags: plastics, laminated, and coated*	*3%*
SIC2812	*Chemicals and Allied Products - Alkalies and chlorine*	*5%*
SIC2821	*Chemicals and Allied Products - Plastics materials and resins*	*6%*
SIC2833	*Drugs - Medicinals and botanicals*	*4%*
SIC2834	*Drugs - Pharmaceutical preparations*	*4%*
SIC2873	*Agricultural Chemicals - Nitrogenous fertilizers*	*5%*
SIC2895	*Miscellaneous Chemical Products - Carbon black*	*5%*
SIC3081	*Miscellaneous Plastics Products - Unsupported plastics film and sheet*	*4%*
SIC3082	*Miscellaneous Plastics Products - Unsupported plastics profile shapes*	*3%*
SIC3083	*Miscellaneous Plastics Products - Laminated plastics plate and sheet*	*4%*
SIC3085	*Miscellaneous Plastics Products - Plastics bottles*	*2%*
	Firms with only 3-digit industry code	*6%*
SIC283	*Drugs*	*2%*
SIC284	*Soap, Cleaners, and Toilet Goods*	*2%*
SIC289	*Miscellaneous Chemical Products*	*1%*
SIC308	*Miscellaneous Plastics Products*	*1%*

The cluster 'chemicals and allied products' comprises of 1,116 firms with employment and revenue close to the average for the region. It is composed of 218 interconnected industries, where 24 of them are included in the core structure of the cluster, represented in the map above.

The core structure of the cluster is composed of three interconnected segments and one additional segment in the periphery. One of the main segments represents 10 industries from inorganic chemicals including pigments, soap and detergents, wood chemicals, cyclic crudes and intermediaries. One of the industries in this segment – adhesives (SIC 2891) – is situated as a bridge to the second main segment, which represents the fabricated rubber and leather industries, including footwear, hose and belting. The third segment represents 4 industries in the area of miscellaneous plastic products, resins, footwear cut stock, brooms and brushes. There is a distinctive bridge between these last two segments, which is composed of two interconnected industries – rubber and plastics footwear (SIC 3021) and rubber and plastics hose and belting (SIC 3052). The forth small segment in the periphery that is situated like a tail to the inorganic chemicals, represents the detergents, soaps and cleaners industries.

Overall, the cluster is well connected internally, which shows mature inter-industry linkages, or the fact that firms have engaged in related diversification along the value chain. The cluster is also well connected to the 'pharmaceuticals' cluster, to 'furniture' and wood products (via wood substitutes), to 'utilities' (via industrial organic chemicals), and to 'wholesale and trade' cluster.

Map. 13. CLUSTER "OIL & GAS EXTRACTION, REFINING & MINING"

5% of ties between industry codes - based on more than 10 firms
355 firms
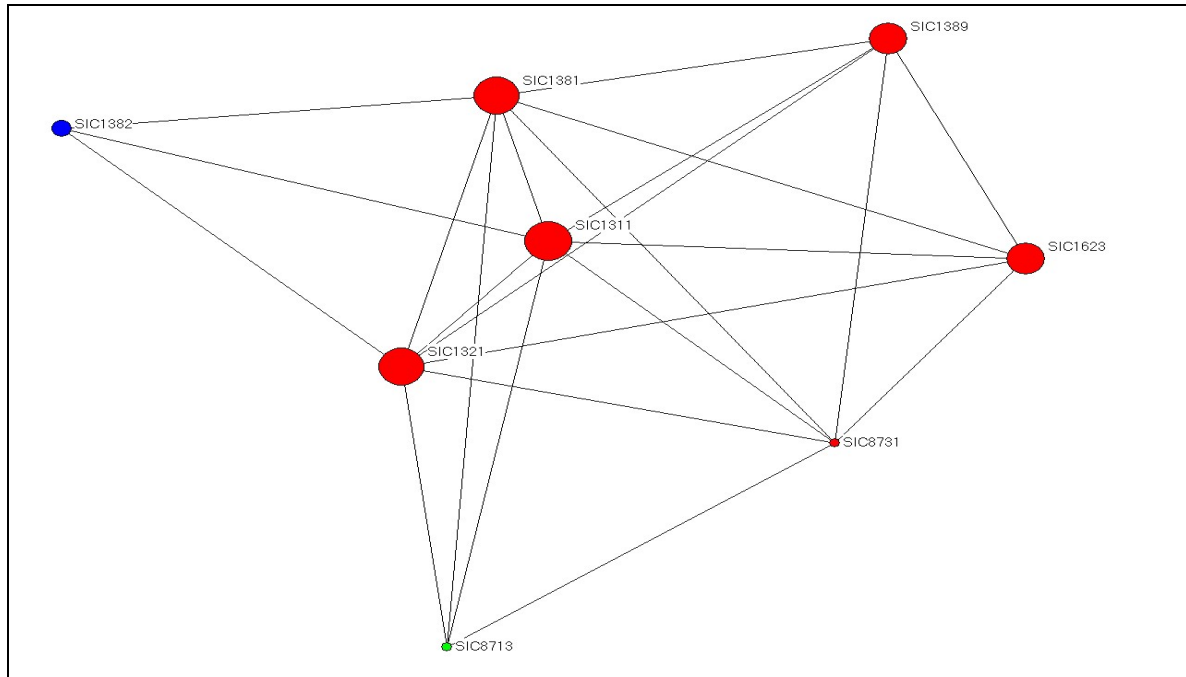
Code	Description	%
SIC1311	Oil and Gas Extraction - Crude petroleum and natural gas	59%
SIC1321	Oil and Gas Extraction - Natural gas liquids	57%
SIC1381	Oil and Gas Extraction - Drilling oil and gas wells	57%
SIC1382	Oil and Gas Extraction - Oil and gas exploration services	17%
SIC1389	Oil and Gas Extraction - Oil and gas field services	46%
SIC1623	Water, sewer, and utility lines	46%
SIC8713	Engineering and Management Services - Surveying services	3%
SIC8731	Engineering and Management Services - Commercial physical research	4%
	Less connected industries	
SIC5541	*Gasoline service stations*	*27%*
	Firms with only 3-digit industry code	*5%*
SIC122	*Bituminous Coal and Lignite Mining*	*1%*
SIC291	*Petroleum Refining*	*4%*

The cluster 'oil and gas extraction, refining and mining' has 355 firms that operate in 66 industries. It employs over 17,000 staff and generates revenue per firm which is one of the highest in the region. This suggests that the cluster is comprised of relatively large and diversified firms (average 4 industries per firm – see Table 3.). The core structure of the cluster is represented by a single interconnected component with 8 industries in it. Interesting observation of the core is that it comprises of oil and gas extraction industries along with water, sewer and utility lines, and two industry codes for engineering and management consulting services including commercial physical research and surveying services.

The cluster includes a large number of gasoline stations (SIC 5541), which remain unconnected to the main core industries represented in the structure, but which appear in Map 32, *Segment C*). In addition, the cluster is connected to the 'construction' cluster (via heavy construction of utility lines), to the 'motor trade' cluster (via the gasoline stations), and to the 'wholesale trade' cluster (see Table 3.).

Map. 14. CLUSTER "MOTOR SPORT, AUTOMOTIVE TRADE & REPAIR"
5% of ties between industry codes - based on more than 142 firms
3,437 firms

Code	Description	%
SIC5012	Wholesale Trade - Automobiles and other motor vehicles	48%
SIC5013	Wholesale Trade - Motor vehicle supplies and new parts	18%
SIC5014	Wholesale Trade - Tires and tubes	18%
SIC5015	Wholesale Trade - Motor vehicle parts, used	18%
SIC5271	Wholesale Trade - Mobile home dealers	51%
SIC5511	Automotive Dealers and Service Stations - New and used car dealers	51%
SIC5521	Automotive Dealers and Service Stations - Used car dealers	51%
SIC5531	Automotive Dealers and Service Stations - Auto and home supply stores	22%
SIC5541	Automotive Dealers and Service Stations - Gasoline service stations	39%
SIC5561	Automotive Dealers and Service Stations - Recreational vehicle dealers	43%
SIC5599	Automotive dealers	51%
SIC7513	Auto Repair, Services, and Parking - Truck rental and leasing, no drivers	7%
SIC7514	Auto Repair, Services, and Parking - Passenger car rental	7%
SIC7515	Auto Repair, Services, and Parking - Passenger car leasing	7%
SIC7519	Auto Repair, Services, and Parking - Utility trailer rental	7%
SIC7521	Automobile parking	32%
SIC7532	Automotive Repair Shops - Top and body repair and paint shops	32%
SIC7533	Automotive Repair Shops - Auto exhaust system repair shops	37%
SIC7536	Automotive Repair Shops - Automotive glass replacement shops	36%
SIC7537	Automotive Repair Shops - Automotive transmission repair shops	37%
SIC7538	Automotive Repair Shops - General automotive repair shops	40%
SIC7539	Automotive repair shops	36%
SIC7542	Automotive Services - Carwashes	35%
SIC7549	Automotive Services - Automotive services	32%
	Less connected industries	
SIC5571	*Motorcycle dealers*	*3%*
	Firms with only 3-digit industry code	*0%*

The cluster 'motor sport, automotive trade and repair' comprises of 3,437 firms that operate in 230 industries. The cluster is making a relatively large contribution to the regional revenue, while the average employment per firm in the cluster is similar to the average employment per firm for the region. The core of the cluster has two quite separate components.

The small component includes four main interconnected industries – in the field of auto-repair, services, parking, car and truck rental and leasing. This component reflects a small proportion of the firms in the cluster. The second component is very large, and comprises of 20 main industries that represent the core of the cluster activities. The industries in this component are very densely interconnected, where automotive dealers, service stations, automotive repair shops and automotive wholesale trade are all intertwined.

Although the cluster is very densely connected, it is also well interconnected to other clusters in the region, such as 'oil and gas' (through the petrol stations that share industry codes in both clusters). The 'motor trade' cluster is also connected to the 'industrial machinery' (via industrial trucks and tractors), 'transport equipment and aircraft' (via motor vehicles parts and accessories), 'transportation services' (via automotive services), 'miscellaneous consumer products' and 'wholesale and trade' (see Table 3.).

Map. 15. CLUSTER "TRANSPORTATION SERVICES"
5% of ties between industry codes based on more than 15 firms
3,583 firms
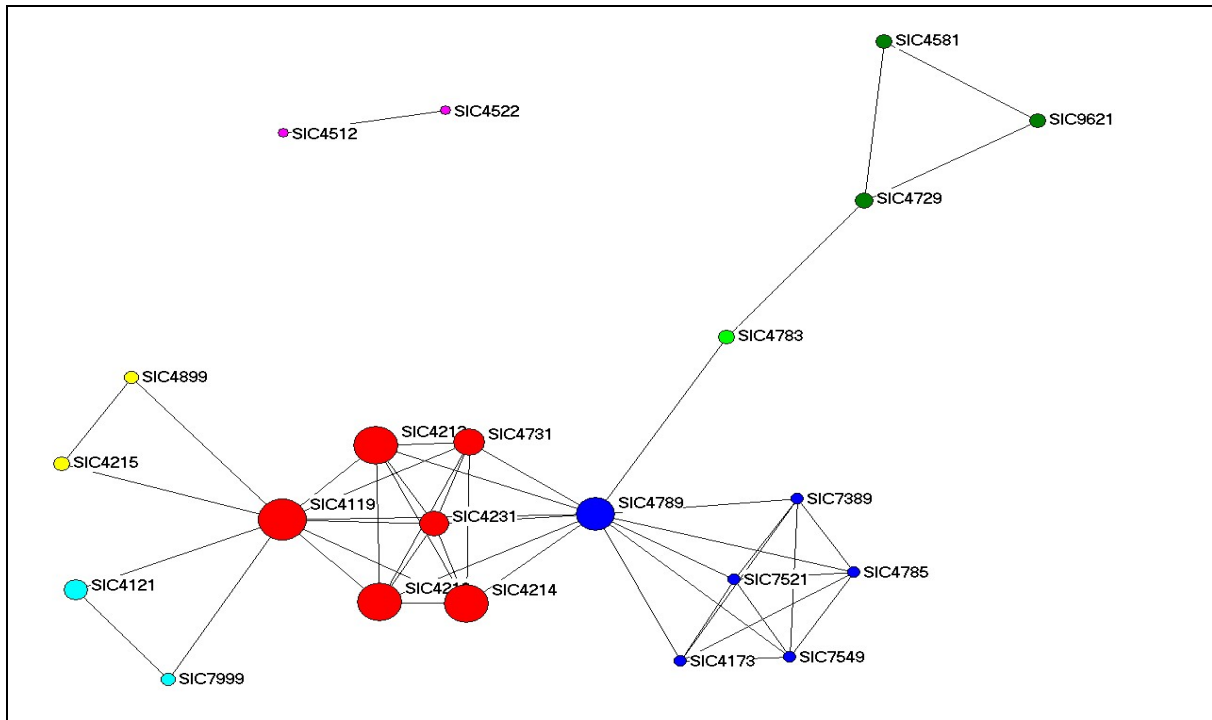
Code	Description	%
SIC4119	Local passenger transportation	31%
SIC4121	Taxicabs	11%
SIC4173	Bus terminal and service facilities	2%
SIC4212	Local trucking, without storage	28%
SIC4213	Trucking, except local	28%
SIC4214	Local trucking with storage	27%
SIC4215	Courier services, except by air	4%
SIC4231	Trucking terminal facilities	16%
SIC4512	Air transportation, scheduled	0,5%
SIC4522	Air transportation, non-scheduled	1%
SIC4581	Airports, flying fields, and services	5%
SIC4729	Passenger transport arrangement	7%
SIC4731	Freight transportation arrangement	17%
SIC4783	Miscellaneous Transportation Services - Packing and crating	5%
SIC4785	Miscellaneous Transportation Services - Inspection and fixed facilities	2%
SIC4789	Transportation services	23%
SIC4899	Communication services	4%
SIC7389	Miscellaneous Repair Services	3%
SIC7521	Automobile parking	2%
SIC7549	Automotive Services - Automotive services	2%
SIC7999	Amusement and recreation	4%
SIC9621	Regulation, admin. of transportation	5%
	Firms with only 3-digit industry code	*29%*
SIC401	*Railroads*	*2%*
SIC414	*Bus Charter Service*	*3%*
SIC452	*Air Transportation, Non-scheduled*	*7%*
SIC472	*Passenger Transportation Arrangement*	*17%*

The cluster 'transportation services' has 3,583 firms in it, and a very complex structure. Its employment and revenue per firm are close to the regional average. The cluster encompasses 165 industries, and 22 of them are represented in the core structure. Nearly a third of the firms in the cluster, however, have declared only one 3-digit industry code as area of operations and do not contribute to the shape of the core structure of the cluster.

The cluster has two main cluster centres that connect 4 segments. The two cluster centres are two generic industry codes for local passenger transportation (SIC 4119) and for transportation services (SIC 4789). The main structural segment with the largest number of firms contains both centres and represents trucking and freight services. The second significant segment displayed as a tail contains four industries related to airport activities and administration of transportation. The third component contains five interconnected industries that represent activities related to parking services and buss terminals, or services that support the two major international airports in the region – Gatwick and Heathrow.

There are two small segments associated with the local passenger transportation. One of them encompasses courier and communication services (SIC 4215, 4899), and the other – taxicabs and entertainment (SIC 4121, 7999). These specialisations in transportation services show peripheral activities to the main value chain in the cluster which is related to air and road transportation. The last and disconnected component is focused on scheduled and non-scheduled air transportation (SIC 4512, 4522).

Overall the cluster is highly connected to other clusters such as: 'marine technologies', 'trucking and warehousing', 'motor sport', and 'communication services' (see Map 34. and Table 3.)

Map. 16. CLUSTER "TRUCKING & WAREHOUSING"

5% of ties between industry codes - based on more than 14 firms

425 firms
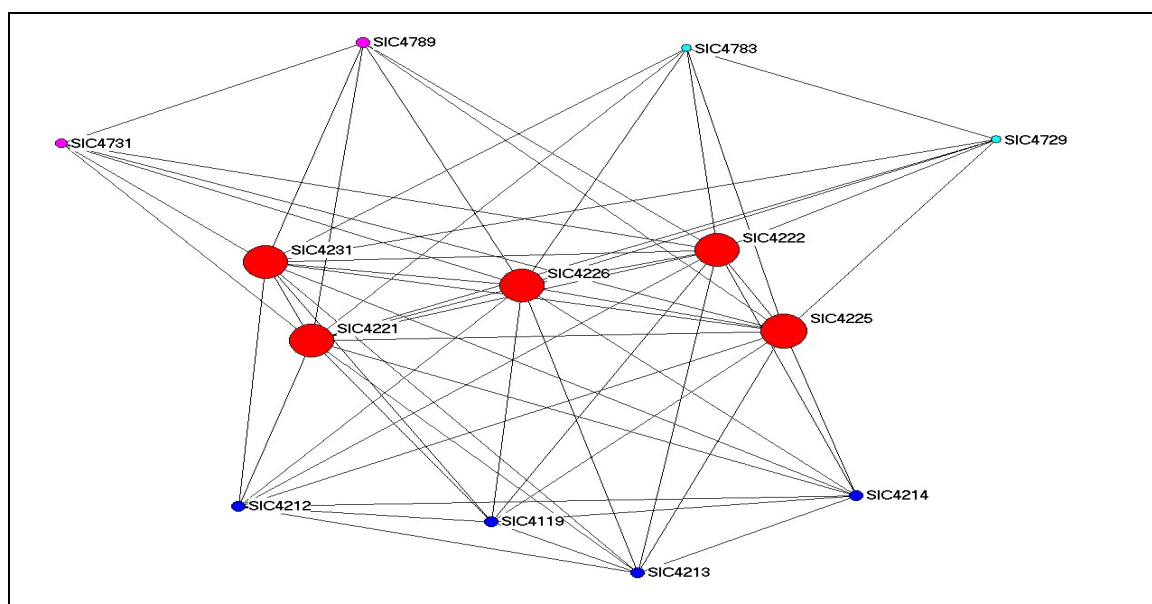
Code	Description	%
SIC4119	Local passenger transportation	14%
SIC4212	Local trucking, without storage	15%
SIC4213	Trucking, except local	15%
SIC4214	Local trucking with storage	13%
SIC4221	Farm product warehousing and storage	96%
SIC4222	Refrigerated warehousing and storage	96%
SIC4225	General warehousing and storage	99%
SIC4226	Special warehousing and storage	96%
SIC4231	Trucking terminal facilities	96%
SIC4729	Passenger transport arrangement	5%
SIC4731	Freight transportation arrangement	6%
SIC4783	Miscellaneous Transportation Services - Packing and crating	5%
SIC4789	Transportation services	11%
	Firms with only 3-digit industry code	*0%*

This is one of the smallest clusters in the region but with distinctive character. This group of firms separated from the transportation services cluster at a very early stage of clustering. The cluster contains 425 firms that operate in 130 industries. Thirteen of these industries are represented in the core cluster structure, which comprises of one main interconnected component with five core industries and three peripheral segments. The central segment comprises of industries related to warehousing and storage activities (SIC 4221, 4222, 4225, 4226, 4231). The segment at the lower part of the Map contains four industries related to local trucking, while the upper two segments encompass industry 'support' activities to warehousing, such as packing, crating, passenger and freight arrangements. The cluster is connected to 'marine technologies' and 'transportation services' clusters.

5% of ties between industry codes - based on more than 12 firms
356 firms
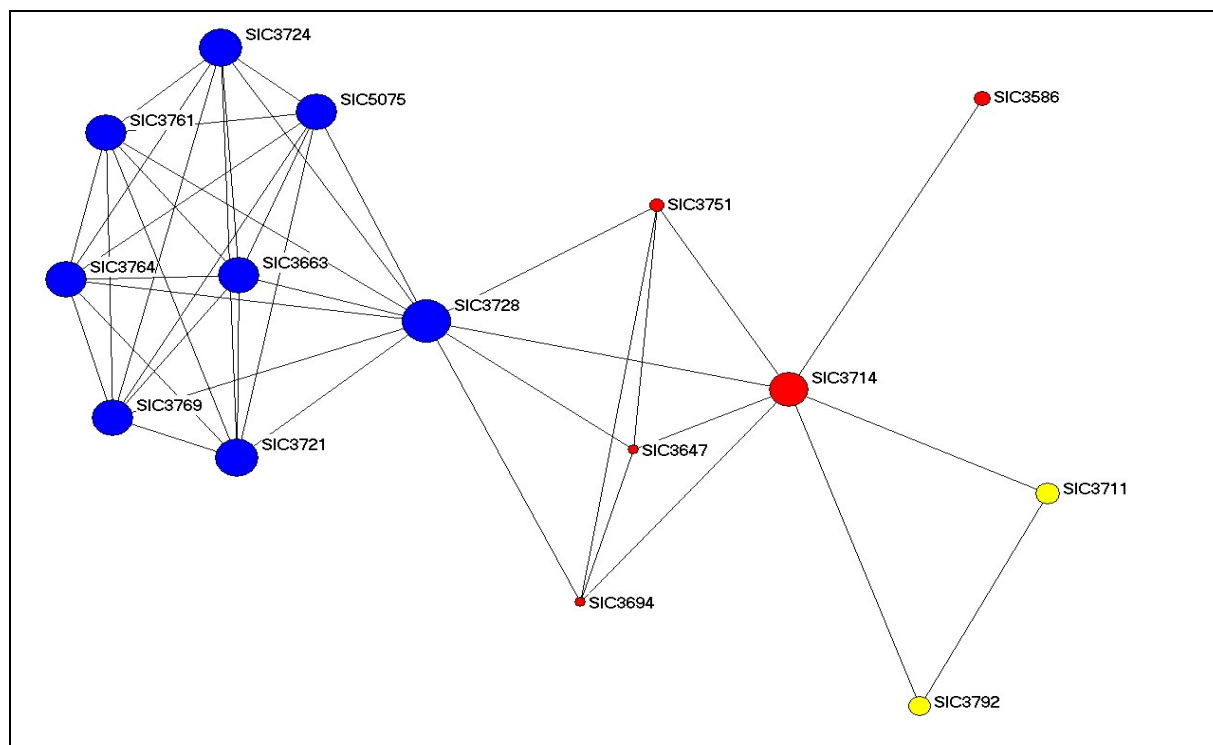
Code	Description	%
SIC3586	Industrial Machinery and Equipment - Measuring and dispensing pumps	10%
SIC3647	Electric Lighting and Wiring Equipment - Vehicular lighting equipment	4%
SIC3663	Radio and TV communications equipment	40%
SIC3694	Misc. Electrical Equipment and Supplies - Engine electrical equipment	4%
SIC3711	Transportation Equipment - Motor vehicles and car bodies	19%
SIC3714	Transportation Equipment - Motor vehicle parts and accessories	38%
SIC3721	Transportation Equipment - Aircraft	42%
SIC3724	Transportation Equipment - Aircraft engines and engine parts	41%
SIC3728	Transportation Equipment - Aircraft parts and equipment	49%
SIC3751	Transportation Equipment - Motorcycles, bicycles, and parts	8%
SIC3761	Guided missiles and space vehicles	41%
SIC3764	Space propulsion units and parts	40%
SIC3769	Space vehicle equipment	40%
SIC3792	Miscellaneous Transportation Equipment - Travel trailers and campers	17%
SIC5075	Wholesale Trade - Warm air heating and air-conditioning	41%
	Firms with only 3-digit industry code	*8%*
SIC371	*Motor Vehicles and Equipment*	*8%*

This is another small cluster with 356 firms operating in 101 industries, fifteen of which represent the core structure of the cluster. It has two cluster centres directly connected – one related to aircraft parts (SIC 3728), and the other related to motor vehicle parts (SIC 3714). The dominant inter-industry segment represents the aircraft and space vehicles industries, which are densely interconnected. Around the motor vehicle parts centre there are three segments that represent car

bodies and miscellaneous transport vehicles (SIC 3711, 3792), measuring equipment (SIC 3586), and electrical equipment and motorcycles (3647, 3694, 3751). The last segment is shared by the aircraft and space vehicles and the motor vehicle parts. There are also 8% of the firms that are not exhibited on this map, as they declare only one 3-digit code for motor vehicles and equipment (SIC 371).

The cluster is interconnected to the 'industrial machinery and ICT equipment' cluster and to the 'motor trade' cluster (see Map 32., *Segment C*., Map 34., Table 3.). What is evident from the Map 17. is that the motor sport cluster, identified by the DTI report (2001) is densely interconnected with the aircraft industry.

Map. 18. CLUSTER "MARINE TECHNOLOGIES EQUIPMENT & SERVICES"
5% of ties between industry codes - based on more than 11 firms
586 firms
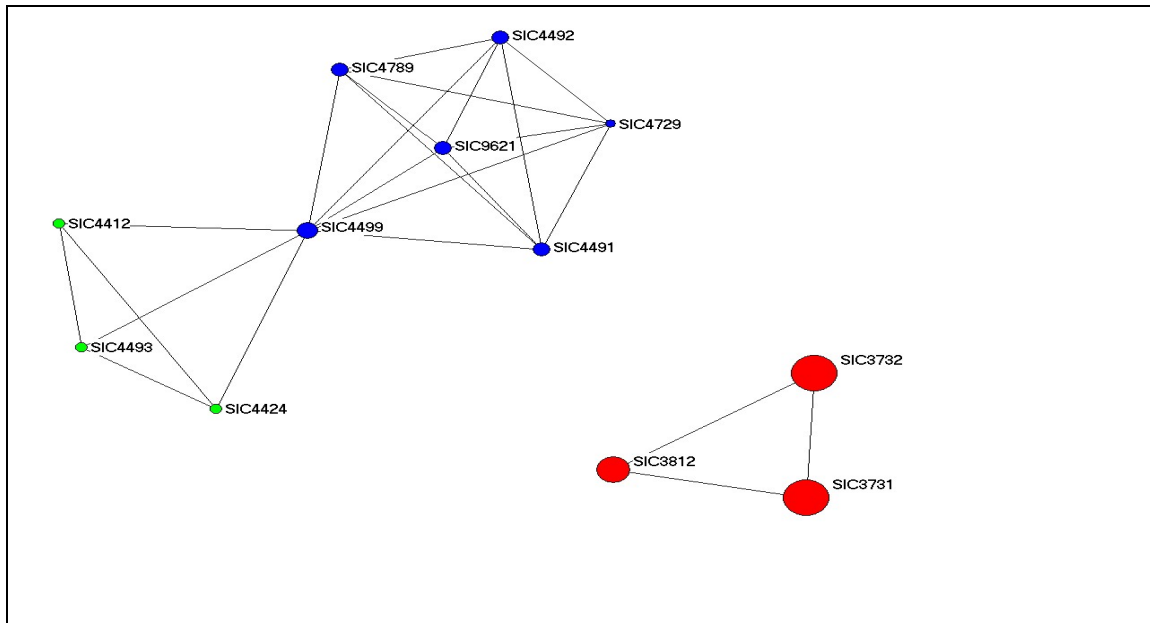
Code	Description	%
SIC3731	Ship building and repairing	47%
SIC3732	Boat building and repairing	46%
SIC3812	Instruments and Related Products - Search and navigation equipment	31%
SIC4412	Water Transportation - Deep sea foreign transportation of freight	4%
SIC4424	Water Transportation - Deep sea domestic transportation of freight	4%
SIC4491	Water Transportation - Marine cargo handling	12%
SIC4492	Water Transportation - Towing and tugboat service	12%
SIC4493	Water Transportation - Marinas	4%
SIC4499	Water Transportation - Water transportation services	15%
SIC4729	Passenger transport arrangement	3%
SIC4789	Transportation services	10%
SIC9621	Regulation, administration of transportation	12%
	Firms with only 3-digit industry code	*38%*
SIC448	*Water Transportation of Passengers*	*6%*
SIC449	*Water Transportation Services*	*32%*

This small cluster comprises of 586 firms, operating in 77 industries, twelve of which form its core structure. The core structure itself has two disconnected components – one which holds the three main industries in ship building, repair and navigation equipment (SIC 3731, 3732, 3812), and the other – related to marine services. The marine services component has two segments – one related to deep sea transportation of freight and marinas (SIC 4412, 4424, 4493), and the other representing all other interconnected water transportation services. The 'marine technology' cluster is interconnected to a number of other clusters, such as: 'instrumentation', 'utilities', 'transportation services', 'trucking and warehousing', and 'non-classified establishments'. This suggests that firms in this cluster seek synergies and growth in other clusters.

70

CLUSTER "INDUSTRIAL MACHINERY, ICT EQUIPMENT & METAL PRODUCTS"

3% of ties between industry codes - based on more than 150 firms

5,406 firms
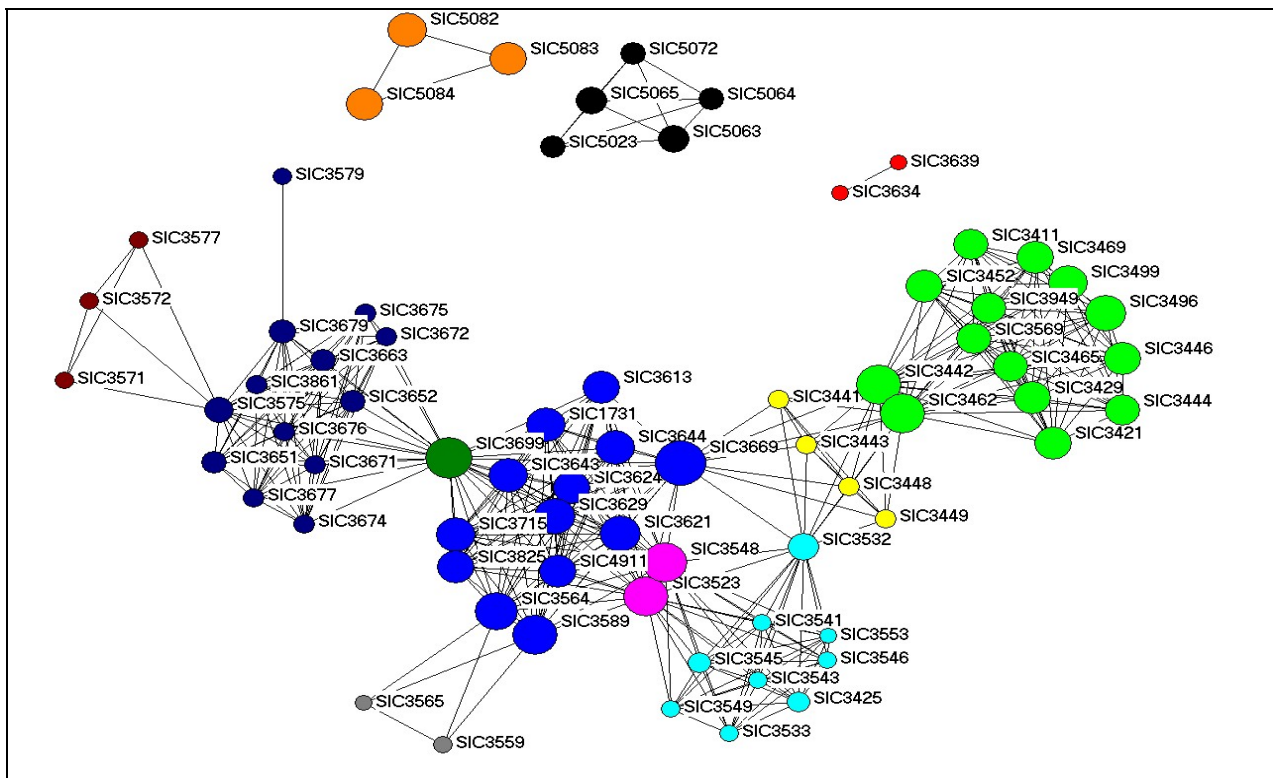
Code	Description	%
SIC1731	Special Trade Contractors - Electrical work	14%
SIC3411	Fabricated Metal Products - Metal cans	12%
SIC3421	Fabricated Metal Products - Cutlery	13%
SIC3425	Fabricated Metal Products - Saw blades and handsaws	6%
SIC3429	Fabricated Metal Products - Hardware	13%
SIC3441	Fabricated Metal Products - Fabricated structural metal	5%
SIC3442	Fabricated Metal Products - Metal doors, sash, and trim	17%
SIC3443	Fabricated Metal Products - Fabricated plate work (boiler shops)	5%
SIC3444	Fabricated Metal Products - Sheet metalwork	13%
SIC3446	Fabricated Metal Products - Architectural metal work	13%
SIC3448	Fabricated Metal Products - Prefabricated metal buildings	5%
SIC3449	Fabricated Metal Products - Miscellaneous metal work	5%
SIC3452	Fabricated Metal Products - Bolts, nuts, rivets, and washers	13%
SIC3462	Fabricated Metal Products - Iron and steel forgings	18%
SIC3465	Fabricated Metal Products - Automotive stampings	13%
SIC3469	Fabricated Metal Products - Metal stampings	13%
SIC3496	Misc. fabricated wire products	16%
SIC3499	Misc. Fabricated metal products	14%
SIC3523	Farm machinery and equipment	18%
SIC3531	Industrial Machinery and Equipment - Construction machinery	5%
SIC3532	Industrial Machinery and Equipment - Mining machinery	11%
SIC3533	Industrial Machinery and Equipment - Oil and gas field machinery	4%
SIC3541	Industrial Machinery and Equipment - Machine tools, metal cutting types	4%
SIC3543	Industrial Machinery and Equipment - Industrial patterns	4%

71

SIC3545	Metalworking Machinery - Machine tool accessories	6%
SIC3546	Industrial Machinery and Equipment - Power-driven hand-tools	4%
SIC3548	Metalworking Machinery - Welding apparatus	18%
SIC3549	Industrial Machinery and Equipment - Metalworking machinery	4%
SIC3553	Special Industry Machinery - Woodworking machinery	4%
SIC3559	Special industry machinery	4%
SIC3564	General Industrial Machinery - Blowers and fans	17%
SIC3565	General Industrial Machinery - Packaging machinery	3%
SIC3569	General industrial machinery	12%
SIC3571	Electronic computers	5%
SIC3572	Computer storage devices	4%
SIC3575	Computer and Office Equipment - Computer terminals	9%
SIC3577	Computer peripheral equipment	4%
SIC3579	Office machines	4%
SIC3589	Service industry machinery	18%
SIC3599	Industrial machinery	6%
SIC3613	Electric Distribution Equipment - Switchgear and switchboard apparatus	14%
SIC3621	Electrical Industrial Apparatus - Motors and generators	16%
SIC3624	Electrical Industrial Apparatus - Carbon and graphite products	14%
SIC3629	Electrical industrial apparatus	16%
SIC3634	Household Appliances - Electric house-wares and fans	3%
SIC3639	Household appliances	3%
SIC3643	Electric Lighting and Wiring Equipment - Current-carrying wiring devices	15%
SIC3644	Electric Lighting and Wiring Equipment – Non-current-carrying wiring devices	14%
SIC3651	Household audio and video equipment	7%
SIC3652	Pre-recorded records and tapes	8%
SIC3663	Radio and TV communications equipment	7%
SIC3669	Communications equipment	21%
SIC3671	Electronic Components and Accessories - Electron tubes	5%
SIC3672	Electronic Components and Accessories - Printed circuit boards	5%
SIC3674	Electronic Components and Accessories - Semiconductors and related devices	5%
SIC3675	Electronic Components and Accessories - Electronic capacitors	5%
SIC3676	Electronic Components and Accessories - Electronic resistors	5%
SIC3677	Electronic Components and Accessories - Electronic coils and transformers	5%
SIC3679	Electronic Components and Accessories - Electronic components	8%
SIC3699	Electrical equipment and supplies	19%
SIC3715	Transportation Equipment - Truck trailers	14%
SIC3825	Measuring and Controlling Devices - Instruments to measure electricity	14%
SIC3861	Instruments And Related Products - Photographic equipment and supplies	5%
SIC3949	Miscellaneous Manufacturing Industries - Sporting and athletic goods	12%
SIC4911	Electric services	14%
SIC5023	Wholesale Trade – Home-furnishings	7%
SIC5063	Wholesale Trade - Electrical apparatus and equipment	11%
SIC5064	Wholesale Trade - Electrical appliances, TV and radios	8%
SIC5065	Wholesale Trade - Electronic parts and equipment	11%
SIC5072	Wholesale Trade - Hardware	7%
SIC5082	Wholesale Trade - Construction and mining machinery	15%
SIC5083	Wholesale Trade - Farm and garden machinery	13%
SIC5084	Wholesale Trade - Industrial machinery and equipment	13%
	Less connected industries	
SIC3312	*Primary Metal Industries - Blast furnaces and steel mills*	*2%*
SIC3313	*Primary Metal Industries - Electrometallurgical products*	*2%*
SIC3315	*Primary Metal Industries - Steel wire and related products*	*2%*

SIC3317	Primary Metal Industries - Steel pipe and tubes	2%
SIC3423	Hand and edge tools	2%
SIC3511	Industrial Machinery and Equipment - Turbines and turbine generator sets	2%
SIC3524	Industrial Machinery and Equipment - Lawn and garden equipment	3%
SIC3534	Industrial Machinery and Equipment - Elevators and moving stairways	2%
SIC3535	Industrial Machinery and Equipment - Conveyors and conveying equipment	2%
SIC3536	Industrial Machinery and Equipment - Hoists, cranes, and monorails	2%
SIC3537	Industrial Machinery and Equipment - Industrial trucks and tractors	2%
SIC3544	Special dies, tools, jigs & fixtures	2%
SIC3568	Power transmission equipment	3%
SIC3581	Automatic vending machines	3%
SIC3596	Scales and balances, exc. laboratory	3%
SIC3625	Electrical Industrial Apparatus - Relays and industrial controls	2%
	Firms with only 3-digit industry code	4%
SIC356	General Industrial Machinery	2%
SIC366	Communications Equipment	2%

This highly diversified cluster has 5,406 firms. The firms are amongst the largest contributors to the regional revenue and employment (see Table 2.). The cluster overall encompasses activities in 439 industries, and 73 of them are represented in the core structure. Almost all components of the cluster are densely interconnected, and this is the main reason why statistically we were not able to differentiate between fabricated metal products, industrial machinery, the electronics based industries, and information and communication technology industries.

The structure of the cluster comprises of one very large component containing eight distinctive segments, and three additional components that exist quite autonomously. The large component projects very clearly the value chain in the cluster – starting with fabricated metal products segment to the right, connected to four specialised metal work industries (SIC 3441, 3443, 3448, 3449), that are further interconnected simultaneously to two other segments – an industrial machinery segment (via a bridge of SIC 3532) and the main electrical equipment, electronics and instruments segment (via a bridge of SIC 3669). This last segment appears to play a central position in the cluster, and combines both the electrical and electronic industries. Its connection to specialised audio-visual electronics and specialised communication technology segment is via a large bridge of one industry – electrical equipment and supplies (SIC 3699). It is also connected to a small and peripheral segment of general industrial machinery (with 2 industries – SIC 3559, 3565), which remains as part of the main cluster component. The electronics and household audio-visual segment itself is very diverse in its composition. This segment is further connected to two other segments – computers (with 3 industries), and office machines (SIC 3579).

In addition, there are three other small components that are highly interconnected within themselves, but stand apart from the main cluster component. These are: the manufacturing of

household appliances (SIC 3639, 3634), wholesale trade of appliances and apparatus (5 industries), and general wholesale and trade of machinery (SIC 5082, 8384).

The cluster overall is highly interconnected with other clusters such as: 'instrumentation', 'transport equipment and aircraft', 'motor trade', 'software and computer services', 'utilities', 'miscellaneous consumer products', 'construction', 'furniture and fixture' and 'wholesale trade' (Table 3, and Map. 34.). This suggests that this cluster is at the centre of the regional economy, sharing resources across multiple value chains.

Map. 20. CLUSTER "SOFTWARE & COMPUTER SERVICES"
2% of ties between industry codes - based on more than 92 firms
23,993 firms
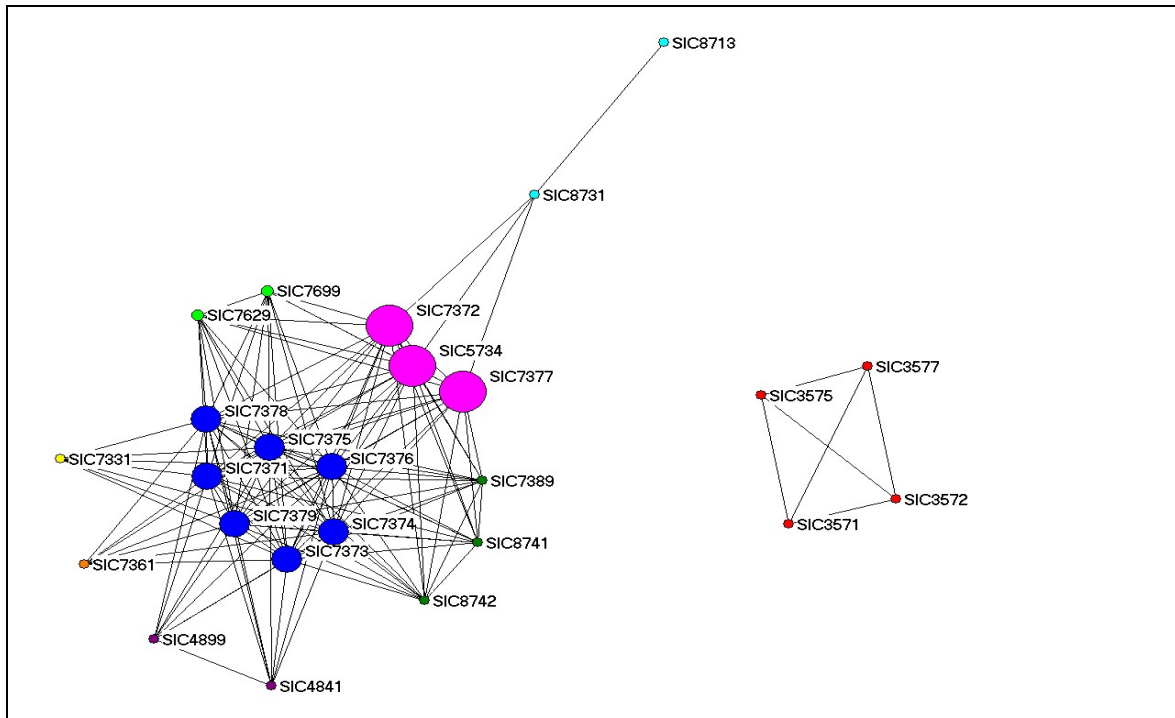
Code	Description	%
SIC3571	Electronic computers	0,5%
SIC3572	Computer storage devices	0,4%
SIC3575	Computer terminals	0,4%
SIC3577	Computer peripheral equipment	0,4%
SIC4841	Cable and other pay TV services	0,4%
SIC4899	Communication services	0,4%
SIC5734	Computer and software stores	70%
SIC7331	Business Services - Direct mail advertising services	0,4%
SIC7361	Business Services - Employment agencies	0,4%
SIC7371	Computer programming services	40%
SIC7372	Pre-packaged software	70%
SIC7373	Computer integrated systems design	40%
SIC7374	Data processing and preparation	40%
SIC7375	Information retrieval services	40%
SIC7376	Computer facilities management	40%
SIC7377	Computer rental and leasing	71%
SIC7378	Computer maintenance and repair	40%
SIC7379	Computer related services	41%
SIC7389	Business services	2%
SIC7629	Electrical repair shops	2%
SIC7699	Repair services	2%
SIC8713	Engineering and Management Services - Surveying services	0,5%
SIC8731	Commercial physical research	0,8%
SIC8741	Management services	1%
SIC8742	Management consulting services	1%
	Firms with only 3-digit industry code	*0%*

This is the third largest cluster in the region in terms of number of registered firms – 23,993 firms in the dataset. At the same time, it is the cluster with the lowest mean of employment per firm (see Table 2). It encompasses 337 industries, and 25 of them are represented in the core structure of the cluster.

The cluster has two components that are situated quite at a distance from each other. One of them is composed of four interconnected industries, and represents the computer manufacturing (SIC 3571, 3572, 3575, 3577). The other component is the dominant one in the cluster and represents a very complex structure of two main segments and a number of peripheral segments and connected industries. Both of the two main segments are very divers agglomerations of industries. One of them is the software segment and includes three interconnected industries of pre-packaged software (SIC 7372), software stores (SIC 5734) and computer rental and leasing (SIC 7377). The other main segment is composed of seven densely interconnected industries that represent the entire spectrum of information and computer services.

These two main segments are surrounded by a periphery of other small connected segments and individual industries that represent different types of business services, management consulting services, communication services, repair services, and commercial physical and engineering research.

This cluster has absorbed a large number of activities from different value chains and demonstrates a very diverse profile of industries. In addition, it is connected to the 'machinery and ICT equipment' cluster and to 'miscellaneous services' cluster.

Map. 21. CLUSTER "INSTRUMENTATION"

3% of ties between industry codes - based on more than 132 firms
1,027 firms
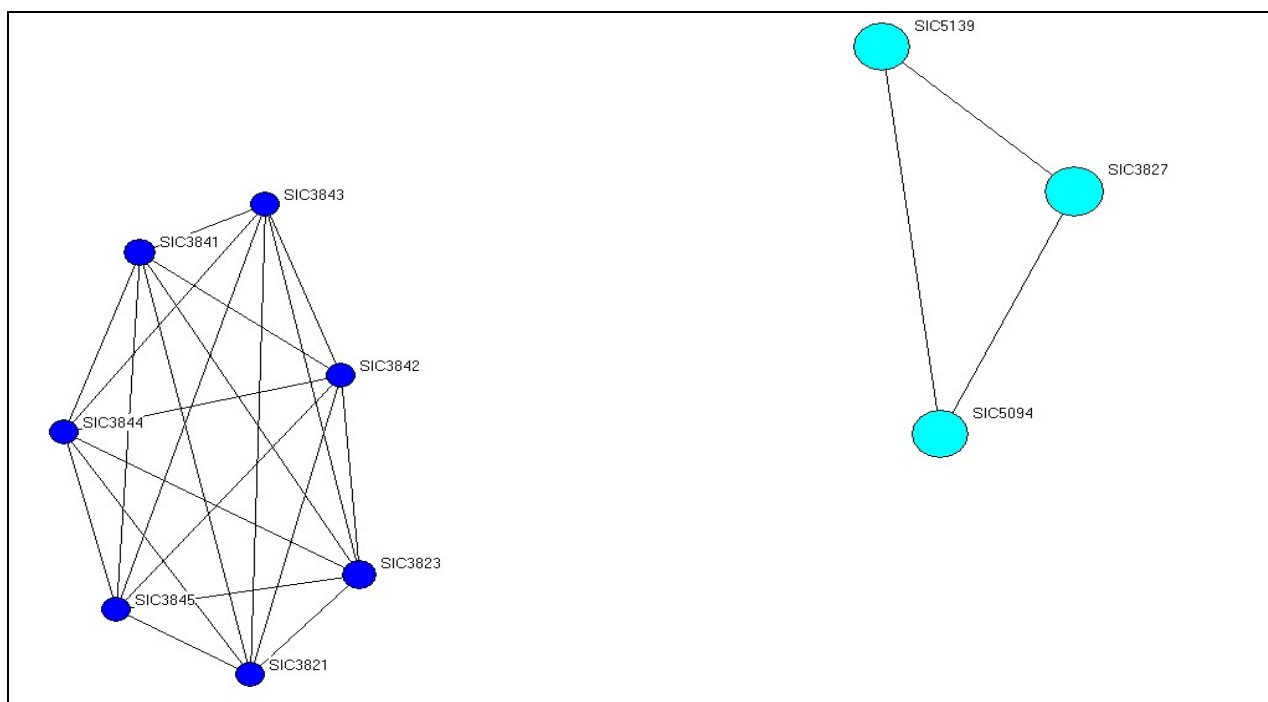
Code	Description	%
SIC3821	Instruments and Related Products - Measuring and Controlling Devices - Laboratory apparatus and furniture	14%
SIC3823	Instruments and Related Products - Measuring and Controlling Devices - Process control instruments	16%
SIC3827	Instruments and Related Products - Measuring and Controlling Devices - Optical instruments and lenses	32%
SIC3841	Medical Instruments and Supplies - Surgical and medical instruments	15%
SIC3842	Medical Instruments and Supplies - Surgical appliances and supplies	14%
SIC3843	Medical Instruments and Supplies - Dental equipment and supplies	13%
SIC3844	Medical Instruments and Supplies - X-ray apparatus and tubes	13%
SIC3845	Medical Instruments and Supplies – Electro-medical equipment	14%
SIC5094	Wholesale Trade - Miscellaneous Durable Goods - Jewellery and precious stones	31%
SIC5139	Wholesale Trade--Nondurable Goods - Footwear	31%
	Less connected industries	
SIC3824	*Instruments and Related Products - Fluid meters and counting devices*	*2%*
	Firms with only 3-digit industry code	*44%*
SIC382	*Measuring and Controlling Devices*	*44%*

The 'instrumentation' cluster has 1,027 firms that provide 1% of the regional employment. It is composed of 128 industries and 10 of these are represented in the cluster core structure. Very large percentage of the firms (44%) have declared only one 3-digit code for measuring and controlling devices, which do not contribute to the overall structure exhibited on Map 21. The cluster is composed of two quite independent components. One of the components incorporates seven interconnected industries which represent primarily medical instruments and supplies and

laboratory apparatus (SIC 3821, 3823, 3841, 3842, 3843, 3844, 3845). The other component contains two wholesale trade industries strongly connected to optical instruments and lenses industry (SIC 3827).

Overall the cluster is interconnected with five other clusters: 'health care services', 'marine technologies', 'industrial machinery and ICT', 'miscellaneous consumer products', and 'whole sale trade' cluster.

Map. 22. CLUSTER "R&D"

3% of ties between industry codes - based on more than 52 firms
3,948 firms
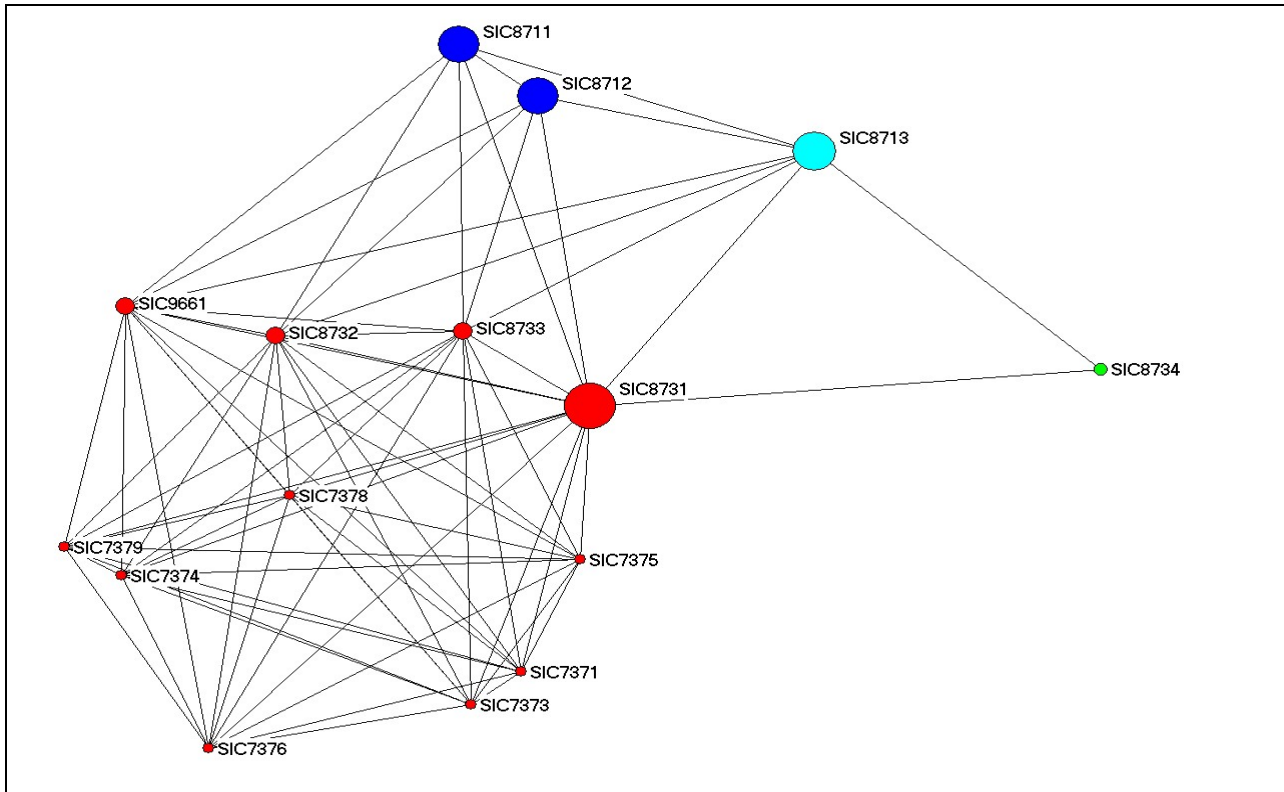
Code	Description	%
SIC7371	Business Services - Computer programming services	2%
SIC7373	Business Services - Computer integrated systems design	2%
SIC7374	Business Services - Data processing and preparation	2%
SIC7375	Business Services - Information retrieval services	2%
SIC7376	Business Services - Computer facilities management	2%
SIC7378	Business Services - Computer maintenance and repair	2%
SIC7379	Business Services - Computer related services	2%
SIC8711	Engineering, Management and Architectural Services - Engineering services	74%
SIC8712	Engineering, Management and Architectural Services - Architectural services	73%
SIC8713	Engineering, Management and Architectural Services - Surveying services	80%
SIC8731	Research and Testing Services - Commercial physical research	99%
SIC8732	Research and Testing Services - Commercial non-physical research	19%
SIC8733	Research and Testing Services – Non-commercial research organizations	19%
SIC8734	Research and Testing Services - Testing laboratories	8%
SIC9661	Administration of Economic Programs - Space research and technology	19%
	Firms with only 3-digit industry code	*0%*

The 'R&D' cluster includes 3,948 firms that contribute 2% of the regional employment and 1% of the regional revenue. The cluster encompasses 250 industries and 15 of them are represented in the core structure of the cluster. The cluster has a clear cluster centre, where 99% of the firms have declared operations in commercial physical research (SIC 8731). Overall, the industries in the

cluster are highly interconnected, including the industry that represents testing laboratories (SIC 8734) and stands at a distance from the main agglomeration.

The cluster is composed of one main component which has three distinctive segments – engineering and architecture services is the top segment (SIC 8711, 8712, 8713); testing laboratories is the second segment (SIC 8734); and the third main segment includes all other industries that represent research and testing services, as well as business services and administration of space research and technology.

The cluster is quite diverse within itself, and is not connected to other clusters in the regions at the level of strength of ties, that were selected for the analysis of the inter-cluster relationships (see Map 34.).
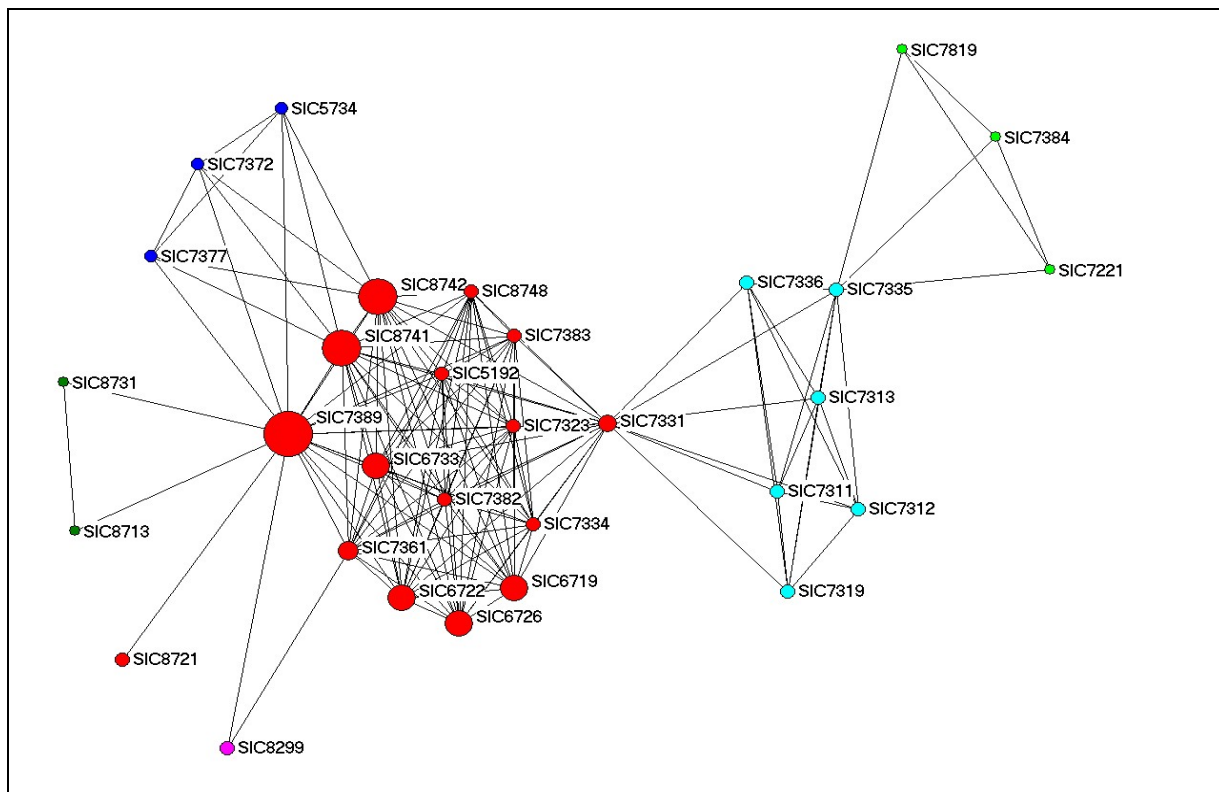
Map. 23. CLUSTER "INVESTMENT, BUSINESS & MANAGEMENT CONSULTING SERVICES"

38,406 firms

Sub-divided into Sub-cluster 1 – with 17,978 firms, and Sub-cluster 2 – with 20,428 firms

Sub-set 1 – 17,978 firms

1% of ties between industry codes - based on more than 273 firms

Sub-set 2 – 20,428 firms

2% of ties between industry codes - based on 20,428 firms
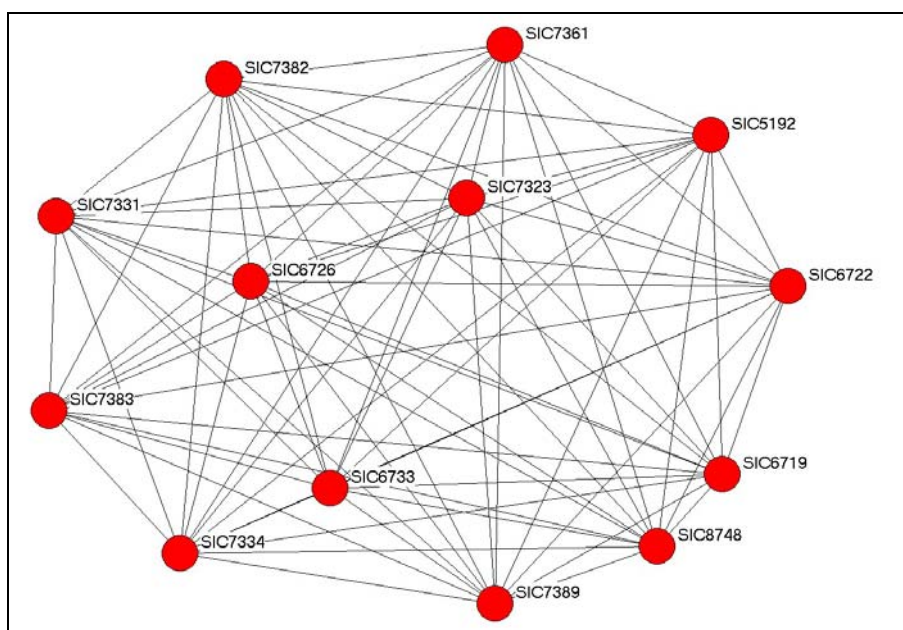
Code	Description	% from total	% from Sub-set 1	% from Sub-set 2
SIC5192	**Wholesale Trade - Books, periodicals, & newspapers**	**57%**	**9%**	**100%**
SIC5734	Computer and software stores	2%	45%	0%
SIC6719	**Holding companies**	**66%**	**28%**	**100%**
SIC6722	**Investment Offices - Management investment, open-end**	**67%**	**29%**	**100%**
SIC6726	**Investment offices**	**67%**	**29%**	**100%**
SIC6733	**Trusts**	**66%**	**28%**	**100%**
SIC7221	Photographic studios, portrait	1%	2%	0%
SIC7311	Advertising agencies	3%	7%	0%
SIC7312	Outdoor advertising services	3%	7%	0%
SIC7313	Radio, TV, publisher representatives	3%	7%	0%
SIC7319	Business Services – Advertising	3%	7%	0%
SIC7323	**Business Services - Credit reporting services**	**57%**	**9%**	**100%**
SIC7331	**Business Services - Direct mail advertising services**	**60%**	**15%**	**100%**
SIC7334	**Photocopying & duplicating services**	**57%**	**9%**	**100%**
SIC7335	Commercial photography	4%	8%	0%
SIC7336	Commercial art and graphic design	3%	7%	0%
SIC7361	**Business Services - Employment agencies**	**61%**	**18%**	**100%**
SIC7372	Pre-packaged software	2%	4%	0%
SIC7377	Computer rental & leasing	2%	4%	0%
SIC7382	**Security systems services**	**58%**	**9%**	**100%**
SIC7383	**Miscellaneous Business Services - News syndicates**	**57%**	**9%**	**100%**
SIC7384	Photofinishing laboratories	1%	2%	0%
SIC7389	**Business services**	**83%**	**63%**	**100%**
SIC7819	Services allied to motion pictures	1%	2%	0%
SIC8299	Schools & educational services	4%	9%	0%
SIC8713	Engineering & Management Services - Surveying services	1%	2%	0%
SIC8721	Accounting, auditing, & bookkeeping	4%	8%	0%
SIC8731	Commercial physical research	1%	2%	0%
SIC8741	Management services	22%	48%	0%
SIC8742	Management consulting services	22%	48%	0%
SIC8748	**Business consulting**	**57%**	**9%**	**100%**
	Firms with only 3-digit industry code	*0%*	*0%*	*0%*

This is the largest cluster in the region comprising of 38,406 firms, operating in 688 industries. It is the largest contributor to the regional employment (34%) and the largest contributor to the regional revenue (31%). Due to limitations in the software for calculating matrices of this size we had to look for alternative methods to generate the cluster map. We split the cluster into two sub-sets, one of which comprised of a single statistical cluster that was generated at the early stage of clustering. This individual subset included 20,428 firms and all of them reported the 13 industries exhibited in sub-set 2. This is clearly the core of the entire cluster as it overlaps completely with the largest segment on the map of the sub-set 1 above. The only exceptions are two management consulting industries (SIC 8741 and SIC 8742), that appear in addition in the large segment of sub-set 1. The industries that are present in the second sub-set of the cluster are described in bold in the table above, which represents the main core of the cluster. The Map of the sub-set 1 however, contains

these inter-industry relations and exhibits how they are connected to the other elements of the core structure of the cluster.

The core structure of the cluster is composed of 32 industries, and 13 of them are represented in the most dominant component on both maps – for sub-set 1 and sub-set 2. These 13 industries represent the business and investment services, including holding companies, trusts, and wholesale trade of periodicals. The other segments of the cluster exhibited in sub-set 1 are relatively small and specialised. One of the segments to the right contains 3 industries that specialise in photographic and photo-finishing services (SIC 7221, 7384, 7819). This segment is connected to a second segment comprising of commercial photography, publishing and advertising (6 industries). On the left-hand side there are four small segments that specialise in software and computer services (3 industries – SIC 5734, 7372, 7377), engineering and commercial physical research (2 industries – SIC 8713, 8731)), accounting and book keeping (SIC 8721), and educational services (SIC 8299). It is clear that many of these specialised activities belong to other clusters, but have been pulled by consulting firms that have broad scope of diversification.

Overall the cluster is interconnected to four other clusters: 'miscellaneous services', 'utilities', 'amusement and recreation', and the 'whole sale trade' cluster.

Map. 24. CLUSTER "FINANCE"

3% of ties between industry codes - based on more than 103 firms
1,912 firms
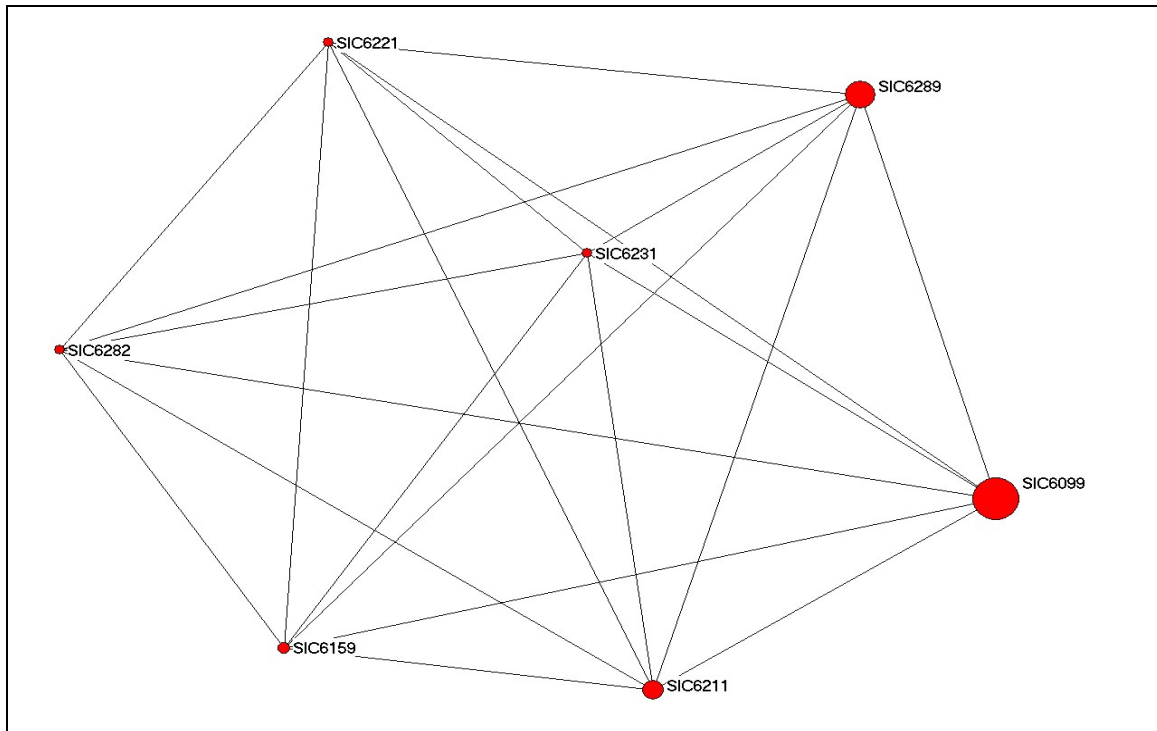
Code	Description	%
SIC6099	Functions related to deposit banking	11%
SIC6159	Misc. business credit institutions	6%
SIC6211	Security brokers and dealers	7%
SIC6221	Commodity contracts brokers, dealers	6%
SIC6231	Security and commodity exchanges	6%
SIC6282	Investment advice	6%
SIC6289	Security and commodity services	9%
	Less connected industries	
SIC6411	*Insurance agents, brokers, & service*	*4%*
	Firms with only 3-digit industry code	*81%*
SIC606	*Credit Unions*	*4%*
SIC628	*Security and Commodity Services*	*3%*
SIC679	*Miscellaneous Investing*	*74%*

This cluster has 1,912 firms that have one of the smallest mean of employment per firm, which suggests that the majority if these firms are very small and micro establishments. The cluster comprises of 66 industries and only 7 of these industries form the core structure of the cluster. Another unique feature of the cluster is that 81% of the firms in it have reported only one 3-digit code and are not represented on the Map. The majority of the firms with one 3-digit code operate in miscellaneous investing (SIC 679). Regarding the formal structure of the cluster, the leading industry is deposit banking (SIC 6099), and the entire component of 7 industries is highly interconnected. The cluster as a whole is not connected to any other clusters in the region.

Map. 25. CLUSTER "PUBLISHING"

3% of ties between industry codes - based on more than 32 firms
3,015 firms
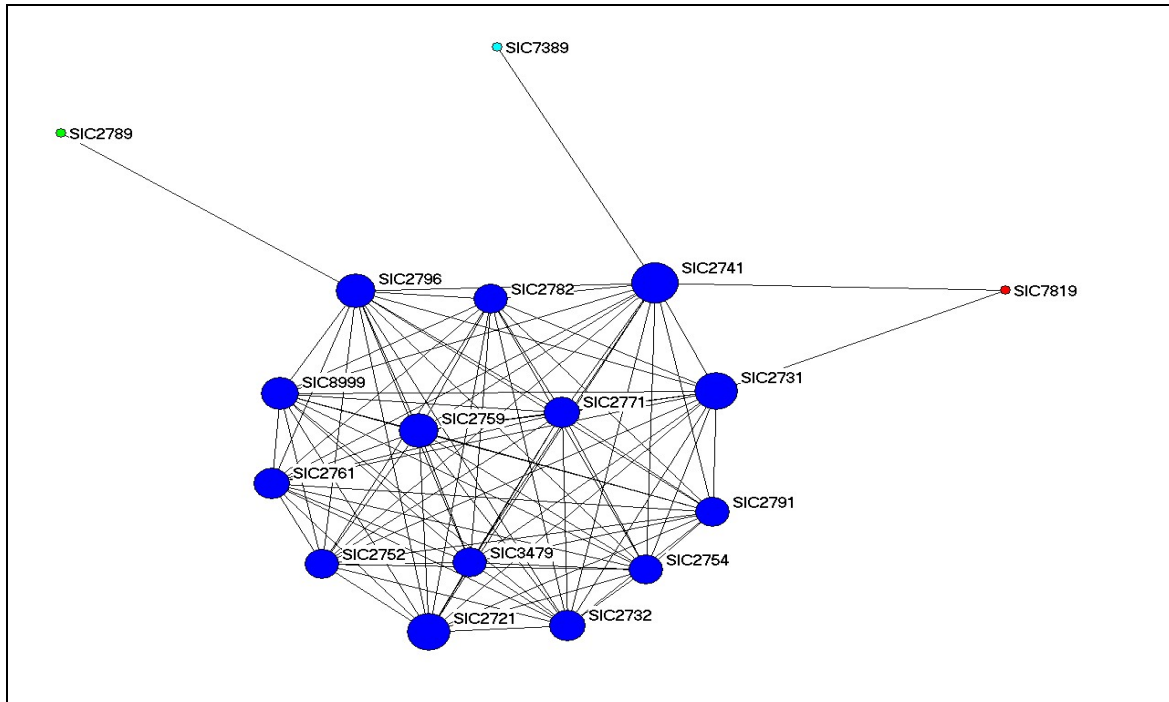
Code	Description	%
SIC2721	Printing and Publishing - Periodicals	62%
SIC2731	Printing and Publishing - Book publishing	61%
SIC2732	Printing and Publishing - Book printing	47%
SIC2741	Printing and Publishing - Miscellaneous publishing	68%
SIC2752	Printing and Publishing - Commercial printing, lithographic	46%
SIC2754	Printing and Publishing - Commercial printing, gravure	45%
SIC2759	Printing and Publishing - Commercial printing	56%
SIC2761	Printing and Publishing - Manifold business forms	47%
SIC2771	Printing and Publishing - Greeting cards	47%
SIC2782	Printing and Publishing – Blank-books and loose-leaf binders	45%
SIC2789	Bookbinding and related work	2%
SIC2791	Printing and Publishing - Typesetting	45%
SIC2796	Printing and Publishing – Plate-making services	54%
SIC3479	Metal coating and allied services	45%
SIC7389	Business services	1%
SIC7819	Services allied to motion pictures	2%
SIC8999	Services	52%
	Less connected industries	
SIC2711	*Printing and Publishing - Newspapers*	*5%*
	Firms with only 3-digit industry code	*2%*
SIC267	*Misc. Converted Paper Products*	*2%*

The cluster 'publishing' includes 3,015 firms that contribute to 2% of the regional employment and 2% of the regional revenue. These firms operate in 190 industries and 17 of these are represented in the core structure of the cluster. The core structure includes one densely interconnected component

where all industries are connected to each other. This suggests very mature cluster composition with depth of diversification. The cluster is also connected to 'miscellaneous consumer products' cluster which shares commercial printing (SIC 2752) (Table 3.).

Map. 26. CLUSTER "WHOLESALE TRADE"
1% of ties between industry codes - based on more than 180 firms
6,113 firms
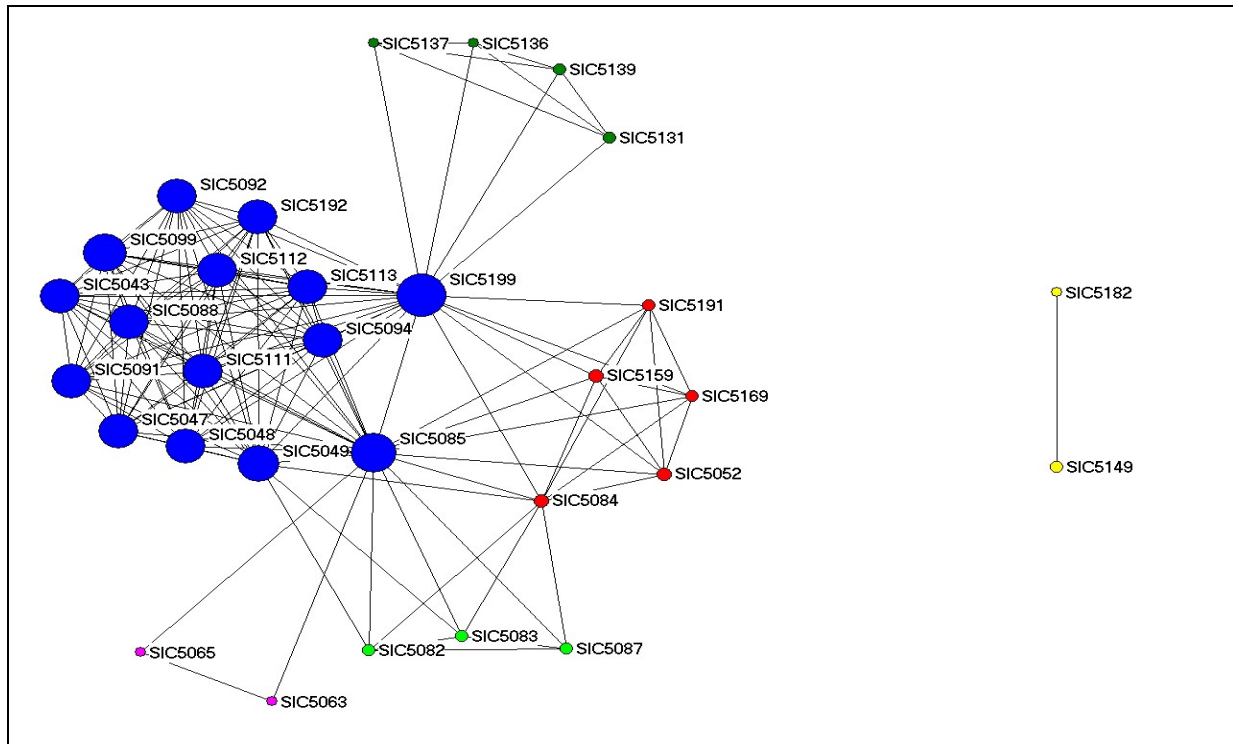
Code	Description	%
SIC5043	Wholesale Trade - Photographic equipment and supplies	56%
SIC5047	Wholesale Trade - Medical and hospital equipment	56%
SIC5048	Wholesale Trade - Ophthalmic goods	56%
SIC5049	Wholesale Trade - Professional equipment	58%
SIC5052	Wholesale Trade - Coal and other minerals and ores	9%
SIC5063	Wholesale Trade - Electrical apparatus and equipment	3%
SIC5065	Wholesale Trade - Electronic parts and equipment	3%
SIC5082	Wholesale Trade - Construction and mining machinery	5%
SIC5083	Wholesale Trade - Farm and garden machinery	7%
SIC5084	Wholesale Trade - Industrial machinery and equipment	10%
SIC5085	Wholesale Trade - Industrial supplies	66%
SIC5087	Wholesale Trade - Service establishment equipment	6%
SIC5088	Wholesale Trade - Transportation equipment and supplies	55%
SIC5091	Wholesale Trade - Sporting and recreational goods	56%
SIC5092	Wholesale Trade - Toys and hobby goods and supplies	56%
SIC5094	Wholesale Trade - Jewellery and precious stones	57%
SIC5099	Wholesale Trade - Durable goods	62%
SIC5111	Wholesale Trade - Printing and writing paper	56%
SIC5112	Wholesale Trade - Stationery and office supplies	55%
SIC5113	Wholesale Trade - Industrial and personal service paper	56%
SIC5131	Wholesale Trade - Piece goods and notions	6%
SIC5136	Wholesale Trade - Men's and boys' clothing	4%
SIC5137	Wholesale Trade - Women's and children's clothing	4%
SIC5139	Wholesale Trade - Footwear	6%
SIC5149	Wholesale Trade - Groceries and related products	5%
SIC5159	Wholesale Trade - Farm-product raw materials	10%

SIC5169	Wholesale Trade - Chemicals and allied products	6%
SIC5182	Wholesale Trade - Wine and distilled beverages	4%
SIC5191	Wholesale Trade - Farm supplies	6%
SIC5192	Wholesale Trade - Books, periodicals and newspapers	56%
SIC5199	Wholesale Trade - Nondurable goods	74%
	Firms with only 3-digit industry code	*5%*
SIC502	*Wholesale Trade - Furniture and Home-furnishings*	*4%*
SIC505	*Wholesale Trade - Metals and Minerals, except Petroleum*	*1%*

The cluster 'wholesale trade' is a relatively large agglomeration of 6,113 firms operating in 562 industry categories. Overall these firms are among the most diversified firms (with average of 11 industry codes per firm – see Table 3.). The cluster is a relatively large contributor to the regional revenue (6%). The firms in the cluster provide 4% of the regional employment (see Table 2.)

Because of the large size of the cluster, we had to reduce the threshold for identifying the strongest links between industries to 1%. The core structure of the cluster on Map 26 represents the core 31 industries, densely interconnected into one dominant component with five segments in it, and a small additional component in the periphery. The main component has one leading segment, pulled by the generic industry code for wholesale trade of durable goods (SIC 5099), and two major bridges to the other segment - wholesale trade of non-durable goods (SIC 5199), and wholesale trade of industrial supplies (SIC 5085). It is clear that the main leading segment is densely interconnected, and firms in it operate both in wholesale of durable and non-durable goods. These firms represent more than half of the entire cluster, or more than 3,000 firms located in the South East of England.

The two bridges located on the edge of the main segment connect four additional segments which are part of the same configuration. The bridge of wholesale trade of non-durable goods (SIC 5199) connects on its own the top segment of wholesale trade of clothing (4 industries – SIC 5131, 5136, 5137, 5139). The second segment is a complex one which represents more specialised wholesale trade firms, and the specialisation is in farm products, minerals, chemicals and industrial machinery and equipment (5 interconnected industries – SIC 5052, 5084, 5159, 5169, 5191). This segment is densely interconnected within itself, and is also connected to both bridges (SIC 5199) and (SIC 5085). The same is true for the third segment that contains three industries related to wholesale trade of specialised industrial machinery (SIC 5082, 5083, 5087). The final segment comprises of two industries in the area of wholesale trade of electrical apparatus and parts (SIC 5065, 5063), and it is connected only to one of the bridges related to wholesale trade of industry supplies (SIC 5085). This cluster is the most interconnected configuration in the region. It shares industry codes with eleven other clusters in the region (see Table 3.)

Map. 27. CLUSTER "RETAIL"

2% of ties between industry codes - based on more than 168 firms
6,133 firms
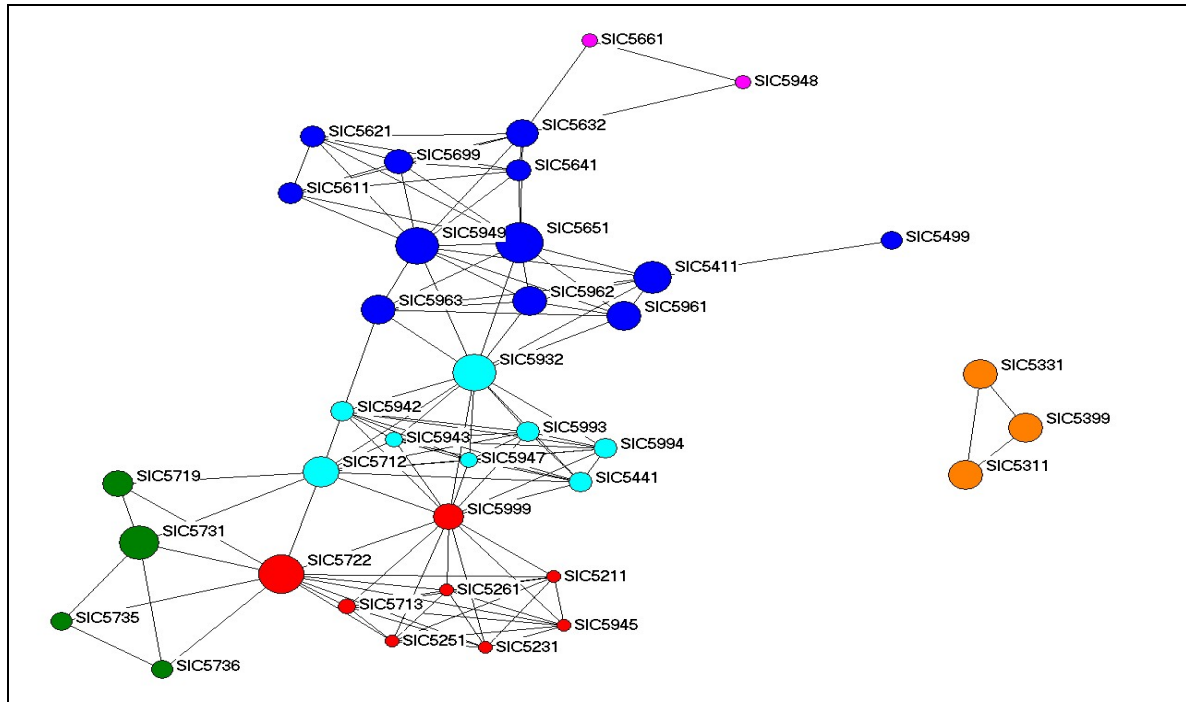
Code	Description	%
SIC5211	Wholesale Trade - Lumber and other building materials	3%
SIC5231	Wholesale Trade - Paint, glass, and wallpaper stores	3%
SIC5251	Wholesale Trade - Hardware stores	3%
SIC5261	Retail nurseries and garden stores	3%
SIC5311	Department stores	13%
SIC5331	Variety stores	13%
SIC5399	Miscellaneous general merchandise stores	13%
SIC5411	Grocery stores	15%
SIC5441	Candy, nut, and confectionery stores	7%
SIC5499	Miscellaneous food stores	6%
SIC5611	Men's and boys' clothing stores	9%
SIC5621	Women's clothing stores	9%
SIC5632	Women's accessory and specialty stores	12%
SIC5641	Children's and infants' wear stores	9%
SIC5651	Family clothing stores	19%
SIC5661	Shoe stores	4%
SIC5699	Miscellaneous apparel and accessory stores	10%
SIC5712	Furniture stores	13%
SIC5713	Floor covering stores	4%
SIC5719	Miscellaneous home-furnishings stores	11%
SIC5722	Household appliance stores	19%
SIC5731	Radio, TV, and electronic stores	16%
SIC5735	Record and pre-recorded tape stores	7%
SIC5736	Musical instrument stores	7%
SIC5932	Used merchandise stores	17%
SIC5942	Book stores	8%
SIC5943	Stationery stores	4%

SIC5945	Hobby, toy, and game shops	3%
SIC5947	Gift, novelty, and souvenir shops	4%
SIC5948	Luggage and leather goods stores	3%
SIC5949	Sewing, needlework, and piece goods	18%
SIC5961	Catalogue and mail-order houses	13%
SIC5962	Merchandising machine operators	13%
SIC5963	Direct selling establishments	13%
SIC5993	Tobacco stores and stands	7%
SIC5994	News dealers and newsstands	7%
SIC5999	Miscellaneous retail stores	11%
	Firms with only 3-digit industry code	*23%*
SIC594	*Miscellaneous shopping goods stores*	*23%*

This is a large cluster containing 6,133 firms that generate 4% of the regional revenue and contribute to 4% of the regional employment. The operations of the firms spread around 343 industries and 37 of these are included in the core structure of the cluster. The cluster is composed of two components - one very large and segmented component and another small and balanced component that contains three interconnected industries related to department stores and variety stores (SIC 5311, 5331, 5399). Overall 13% of the firms in the cluster report activities in this component.

The large and segmented component shows quite complicated inter-industry relationships. There are seven segments and three bridges integrated differently into the dynamics of the component as a whole. At one end of the component are situated two segments – one that specialises in clothing and accessories stores, and another small segment that specialises in shoe, luggage and leather goods (SIC 5661, 5948). This small segment is connected to the clothing and accessories retail. On the other side, the clothing and accessories retail segment is connected to a small segment of groceries and miscellaneous food stores (SIC 5411, 5499), and to another small segment specialising in retail support such as catalogue and mail order houses, direct selling establishments and merchandising machine operators (SIC 5961, 5962, 5963). The last segment is further connected to one of the central bridges for used merchandise stores (SIC 5932), that connect further into a very diversifies segment including variety stores, books, tobacco, candy, stationary, news and furniture retail. Further this segment is connected to another generic bridge for miscellaneous stores (SIC 5999). At the end of this component are situated two additional segments for 'do-it-yourself' (DIY) stores (including lumbering, gardening, paint), and Radio TV and pre-recorded music stores. These two segments are connected in a triangle by a bridge for household appliances stores (SIC 5722) and furniture stores (5712). The complexity of this component shows the diversity within the cluster as a whole. In addition, the cluster is connected to five other clusters in the region – 'food processing', 'hotels and restaurants', 'wholesale trade', health services', and 'miscellaneous services' (see Table 3. and Map 34.).

Map. 28. CLUSTER "HOTELS & RESTAURANTS"

3% of ties between industry codes - based on more than 272 firms
3,100 firms
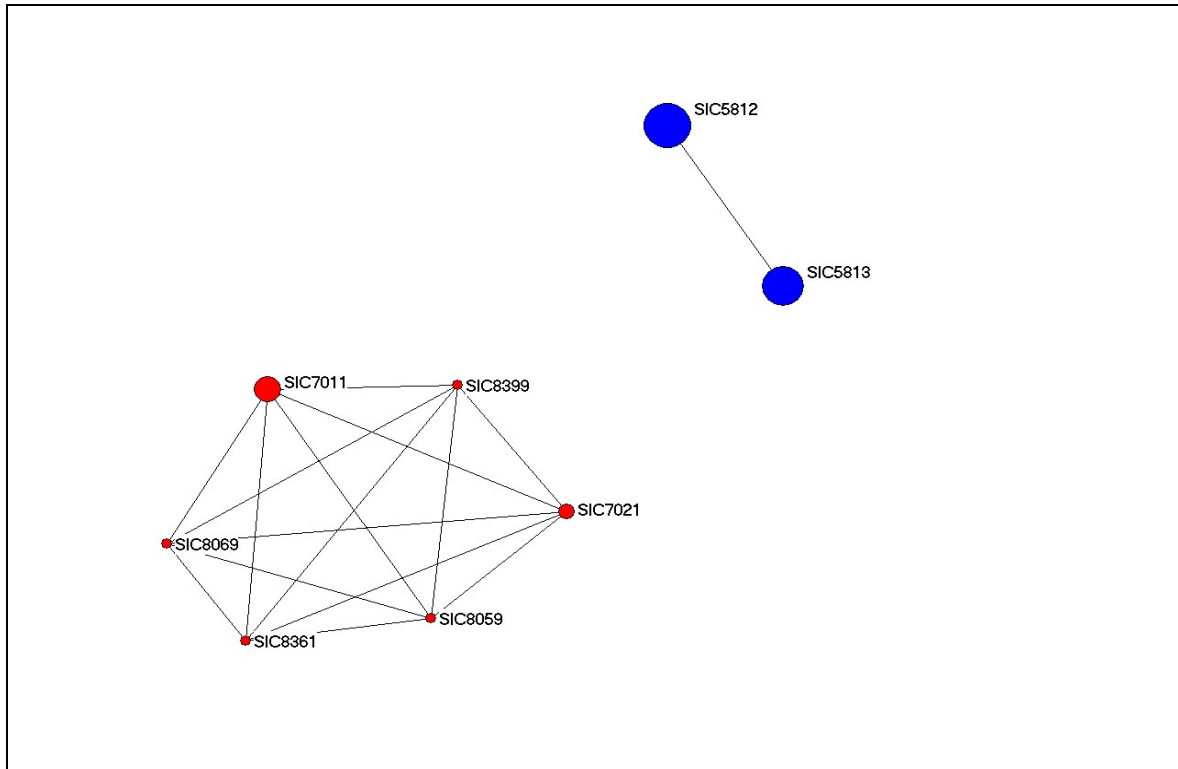
Code	Description	%
SIC5812	Eating places	17%
SIC5813	Drinking places	16%
SIC7011	Hotels and motels	13%
SIC7021	Rooming and boarding houses	10%
SIC8059	Nursing and personal care	9%
SIC8069	Specialty hospitals exc. Psychiatric	9%
SIC8361	Residential care	9%
SIC8399	Social services	9%
	Less connected industries	
SIC8322	*Social Services - Individual and family services*	*9%*
SIC8331	*Social Services - Job training and related services*	*9%*
SIC8351	*Social Services - Child day care services*	*9%*
	Firms with only 3-digit industry code	*68%*
SIC581	*Eating and Drinking Places*	*51%*
SIC701	*Hotels and Motels*	*17%*

This cluster contains 3,100 firms that contribute to 4% of the regional employment and 2% of the regional revenue. The activities of the firms spread in 71 industries and the core structure comprises of eight industries. There are two main components in the core structure of the cluster. One includes six interconnected industries that include hotels and motels, 'bed and breakfast', nursing and specialty hospitals, residential care and social services. The other component contains two main industries related to eating and drinking places (SIC 5812, 5813). A specific feature for the cluster

91

is the large number of firms that have declared only a 3-digit industry code – 68%. Among those we can see the same division as in the cluster - between eating and drinking places, and hotels and motels.

In addition, the cluster overall is connected to four other clusters in the region – 'retail', 'health services', 'miscellaneous services' and 'ultra-diversified' cluster.

Map. 29. CLUSTER "AMUSEMENT & RECREATION SERVICES"
3% of ties between industry codes - based on more than 62 firms
4,988 firms
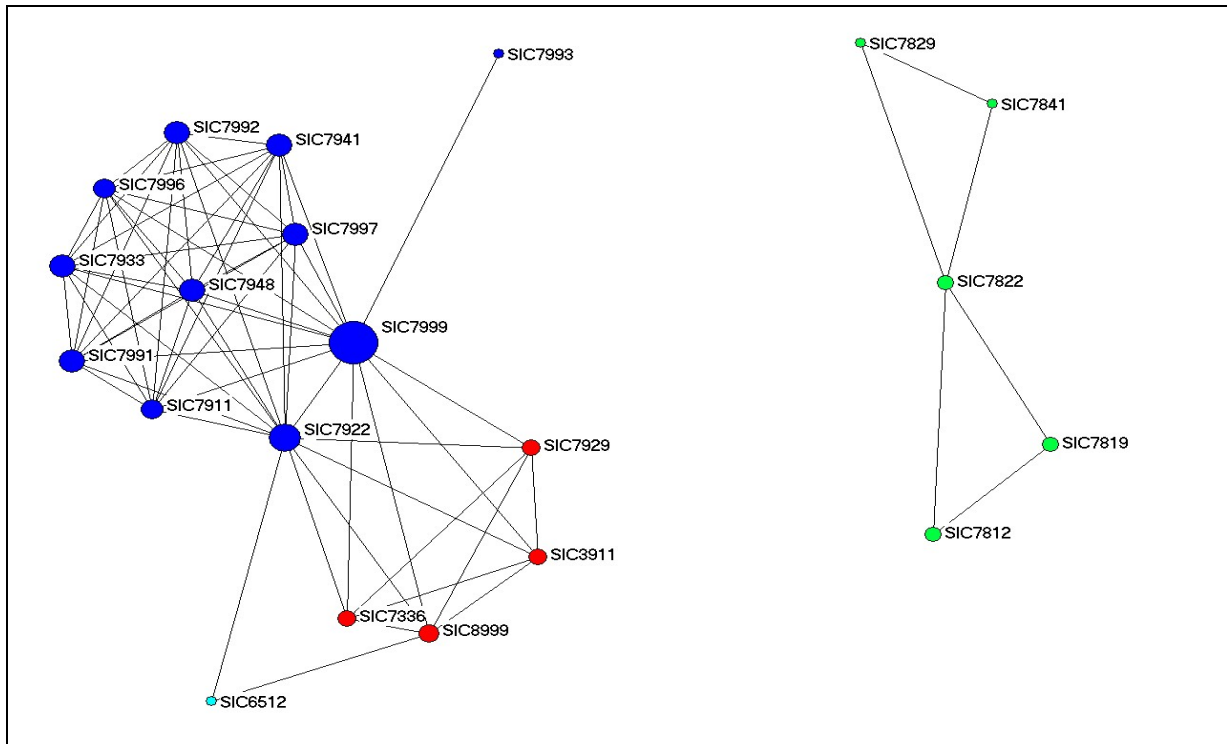
Code	Description	%
SIC3911	Miscellaneous Manufacturing Industries - Jewellery, precious metal	14%
SIC6512	Real Estate – Non residential building operators	2%
SIC7336	Commercial art and graphic design	14%
SIC7812	Motion picture and video production	9%
SIC7819	Services allied to motion pictures	10%
SIC7822	Motion picture and tape distribution	10%
SIC7829	Motion picture distribution services	2%
SIC7841	Video tape rental	2%
SIC7911	Dance studios, schools, and halls	19%
SIC7922	Theatrical producers and services	34%
SIC7929	Entertainers and entertainment groups	14%
SIC7933	Bowling centres	24%
SIC7941	Sports clubs, managers, and promoters	24%
SIC7948	Racing, including track operation	24%
SIC7991	Physical fitness facilities	24%
SIC7992	Public golf courses	24%
SIC7993	Coin-operated amusement devices	3%
SIC7996	Amusement parks	19%
SIC7997	Membership sports and recreation clubs	24%
SIC7999	Amusement and recreation	58%
SIC8999	Services	16%
	Less connected industries	
SIC7033	*Trailer parks and campsites*	*1%*
	Firms with only 3-digit industry code	*29%*
SIC703	*Camps and recreational vehicle parks*	*3%*
SIC792	*Amusement and recreation services - producers, orchestras, entertainers*	*26%*

This is a fairly large cluster with 4,988 firms operating in 200 industries, and 21 of these industries are included in the core structure of the cluster. Although it contains a large number of firms, it contributes only to 1% of the regional employment and half percent of the regional revenue. This suggests that the firms in this cluster are primarily small.

The core structure is composed of two distinctive components that stand quite apart from each other, pulled by other clusters in the region. One of the components is composed of five industries and is more narrowly specialised in motion picture production, distribution, and video rental (SIC 7812, 7819, 7822, 7829, 7841). The other component is more complex and is composed of two segments, connected by two bridging industries. The bridges are a generic industry code for amusements and recreation (SIC 7999), and theatrical producers and services (SIC 7922). These two industries play role in both segments. The larger segment incorporates the traditional recreational activities such as sports clubs and golf courses, parks, racing, bowling, fitness and dance. The smaller segment comprises of four interconnected industries that represent a divers set of activities such as entertainers, commercial art, jewellery and services. These activities clearly do not line in a single value chain, but their integration within individual firms clearly indicates synergies.

This cluster is well connected in the region, and shares industry codes with six other clusters – 'miscellaneous consumer products', 'miscellaneous services', 'communication services', 'publishing', 'health services', and 'ultra-diversified' cluster.

Map. 30. CLUSTER "NON-CLASIFIED ESTABLISHMENTS"
3% of ties between industry codes - based on more than 115 firms
4,700 firms
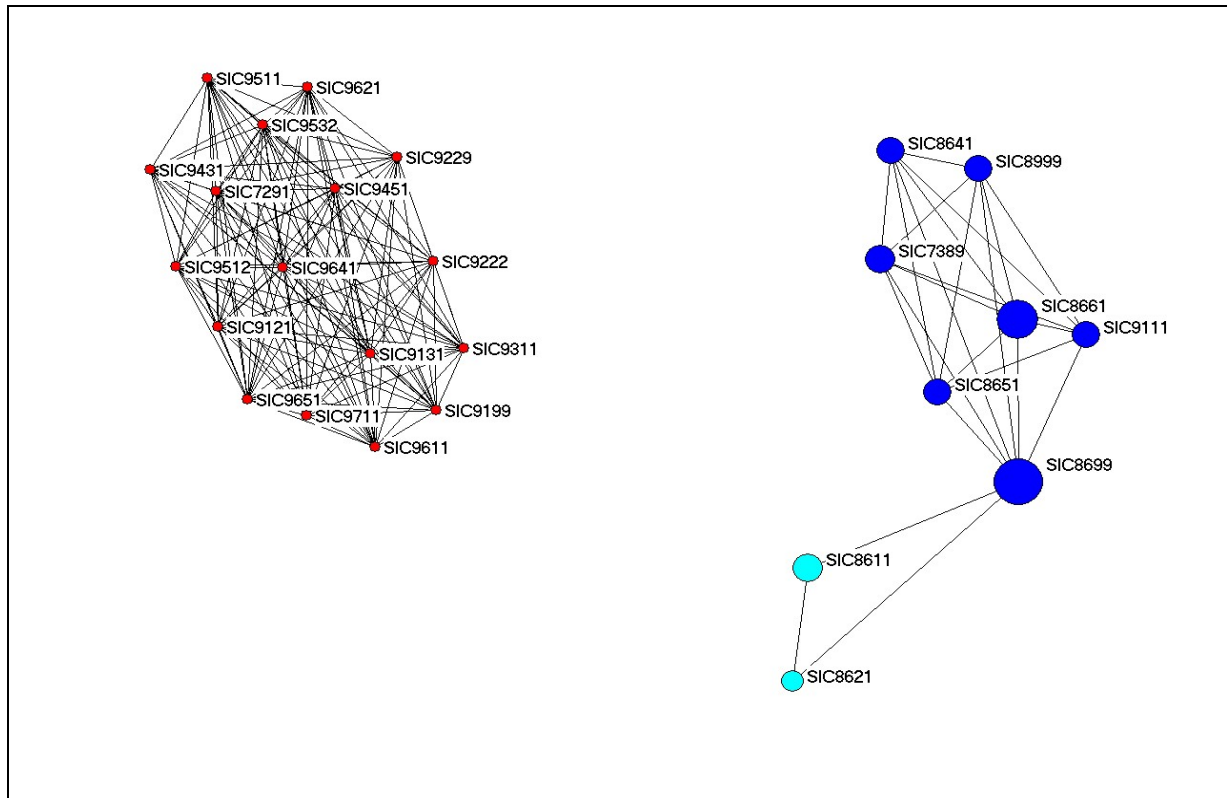
Code	Description	%
SIC7291	Miscellaneous Personal Services - Tax return preparation services	2%
SIC7389	Business services	7%
SIC8611	Membership Organizations - Business associations	7%
SIC8621	Membership Organizations - Professional organizations	5%
SIC8641	Membership Organizations - Civic and social associations	7%
SIC8651	Membership Organizations - Political organizations	7%
SIC8661	Religious organizations	10%
SIC8699	Membership organizations	12%
SIC8999	Services	7%
SIC9111	Executive offices	7%
SIC9121	Legislative bodies	2%
SIC9131	Executive and legislative combined	2%
SIC9199	General government	2%
SIC9222	Legal counsel and prosecution	2%
SIC9229	Public order and safety	2%
SIC9311	Finance, taxation, and monetary policy	2%
SIC9431	Admin. of public health programs	2%
SIC9451	Administration of veterans' affairs	2%
SIC9511	Air, water, and solid waste management	2%
SIC9512	Land, mineral, wildlife conservation	2%
SIC9532	Urban and community development	2%
SIC9611	Admin. of general economic programs	2%
SIC9621	Regulation, admin. of transportation	2%
SIC9641	Regulation of agricultural marketing	2%

SIC9651	Regulation misc. commercial sectors	2%
SIC9711	National security	2%
	Less connected industries	
SIC9221	*Police protection*	*1%*
SIC9721	*International Affairs*	*7%*
	Firms with only 3-digit industry code	*72%*
SIC999	*Non-classifiable establishments*	*72%*

This cluster is unique not only because of its name, but also because of its composition. It is a fairly large cluster with 4,700, and 72% of these firms have declared a 3-digit industry code that is kept for government use only (SIC 999). This was the main reason why this large agglomeration of firms was combined with statistical groups that represent government functions or public institutions.

The remaining 28% of the establishments in this cluster form two distinctive components. One of the components is densely interconnected and represents all government functions related to public administration. The second component has two segments connected by a bridge (SIC 8699 – membership organisations). One of the segments represents only different types of membership organisations (SIC 8611, 8621), while the other segment includes executive offices, business services, political and civic organisations.

Overall this cluster shares two generic industry codes with other clusters in the region. These are (SIC9621) regulation and administration of transportation, which connects the non-classified establishments with 'marine technologies' and 'transportation services'. The other shared code is (SIC8999) for services, which is actively reported by firms in five other clusters in the region – 'publishing', 'amusements and recreation', 'health services', 'miscellaneous services', and 'ultra-diversified' cluster.

Map. 31. CLUSTER "ULTRA DIVERSIFIED"

2% of ties between industry codes - based on more than 38 firms

374 firms
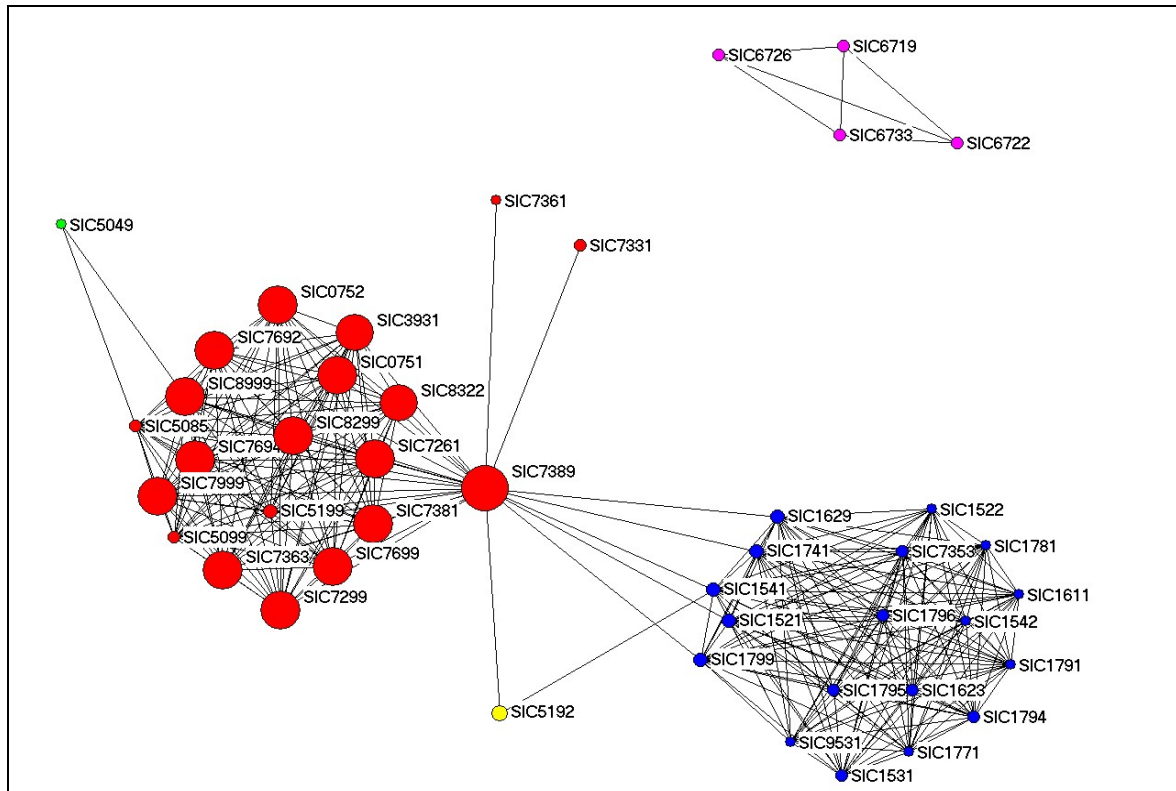
Code	Description	%
SIC0751	Livestock services, exc. Veterinary	63%
SIC0752	Animal specialty services	63%
SIC1521	General Building Contractors - Single-family housing construction	17%
SIC1522	General Building Contractors - Residential construction	11%
SIC1531	General Building Contractors - Operative builders	12%
SIC1541	Non-residential Building Construction - Industrial buildings and warehouses	18%
SIC1542	Non-residential construction	11%
SIC1611	Heavy Construction, Ex. Building - Highway and street construction	11%
SIC1623	Heavy Construction, Ex. Building - Water, sewer, and utility lines	12%
SIC1629	Heavy construction	17%
SIC1741	Special Trade Contractors - Masonry and other stone work	17%
SIC1771	Special Trade Contractors - Concrete work	11%
SIC1781	Special Trade Contractors - Water well drilling	11%
SIC1791	Special Trade Contractors - Structural steel erection	11%
SIC1794	Special Trade Contractors - Excavation work	12%
SIC1795	Special Trade Contractors - Wrecking and demolition work	12%
SIC1796	Special Trade Contractors - Installing building equipment	12%
SIC1799	Special trade contractors	18%
SIC3931	Miscellaneous Manufacturing Industries - Musical instruments	62%
SIC5049	Wholesale Trade - Professional equipment	11%
SIC5085	Wholesale Trade - Industrial supplies	12%
SIC5099	Wholesale Trade - Durable goods	12%
SIC5192	Wholesale Trade - Books, periodicals, and newspapers	20%
SIC5199	Wholesale Trade - Nondurable goods	17%
SIC6719	Holding companies	12%

97

SIC6722	Investment Offices - Management investment, open-end	12%
SIC6726	Investment offices	12%
SIC6733	Trusts	12%
SIC7261	Funeral service and crematories	63%
SIC7299	Miscellaneous personal services	64%
SIC7331	Business Services - Direct mail advertising services	14%
SIC7353	Business Services - Heavy construction equipment rental	12%
SIC7361	Business Services - Employment agencies	10%
SIC7363	Business Services - Help supply services	63%
SIC7381	Detective and armoured car services	63%
SIC7389	Business services	78%
SIC7692	Miscellaneous Repair Shops - Welding repair	63%
SIC7694	Miscellaneous Repair Shops - Armature rewinding shops	63%
SIC7699	Repair services	64%
SIC7999	Amusement and recreation	64%
SIC8299	Schools and educational services	64%
SIC8322	Social Services - Individual and family services	61%
SIC8999	Services	63%
SIC9531	Housing programs	11%
	Firms with only 3-digit industry code	*0%*

This is an unusual agglomeration of 374 firms that have declared extremely diversified portfolio of operations that crosses over many different regional clusters. These are extremely large firms that have average employment per firm 2,676 people, and contribute 3% of the regional employment and 1% of the regional revenue. The cluster encompasses 568 industries, which is the second larges cluster diversification after investment, business and management services. The core structure of the cluster incorporates 44 industries, organised in 2 components. The small component contains four industries related to investment office, holding companies and trusts (SIC 6719, 6722, 6726, 6733). The large component is a very complex agglomeration of industries, organised in two main segments and three additional concentration areas. One of the segments is relatively clear agglomeration of 18 industries that all specialise in heavy and light construction. The other segment is an extremely diverse agglomeration of industries such as: veterinary services, musical instruments, repair services, social services, funeral services, school and education services, amusement and recreation, business services and wholesale trade. The two large segments are bridged by a central industry code for business services (SIC7389), which makes the entire component inseparable. The three additional concentration areas are related to business services (SIC 7361, 7331), wholesale trade of books and periodicals (SIC 5192), and wholesale trade of professional equipment (SIC5049) with a whole range of additional connected wholesale trade industry codes. The level of unrelated diversification in this cluster can not be explained with value-added activities and synergies across different areas of operations and requires further investigation.

With its complexity, this small cluster is connected to seven other clusters in the region: 'industrial machinery and ICT equipment', 'amusement and recreation', 'miscellaneous services', 'hotels and restaurants', 'publishing', 'health services', and 'non-classified establishments' (see Table 3.).

6. Key Findings

Monitoring of economic activities requires an established framework of categories for systematic collection of statistical data and established methodologies. For this purpose each government maintains a list of product categories in which annually information is collected from individual firms. UK industry groups[††††] according to the Inter-Departmental Business Register are described in 10 categories. Within these categories, further 40 industry sectors are identified as divisions[‡‡‡‡]. At the same time, it is recognised that these categories do not represent the real structure of the economy. The UK business cluster report (DTI, 2001) identified 61 clusters[§§§§] located in different regions and at different stages of development. Although many of these cluster categories represent the outcomes of dynamic restructuring across industry and sector boundaries, due to weaknesses in the methodology for their establishment, they do not represent adequately the national and regional economic spaces. This report offers an alternative methodology and alternative map for the structure of the regional economy in the South East of England.

- The most essential advantage of the proposed methodology for multi-stage cluster mapping is that it allows clear allocation of firms in clusters, clear definition of cluster boundaries, and the use of rich data on inter-industry relationships that enable us to draw maps of the core structure of individual clusters, and to study in-depth inter-industry and inter-cluster relationships in the region.

[††††] Agriculture, Production, Construction, Motor trade, Wholesale, Retail, Hotels & catering, Transport, Post & telecom, Finance, Property and business services, Education, Health, Public Administration & Other services.

[‡‡‡‡] Agriculture, Mining & quarrying, Food products, Beverages & tobacco; Textiles & textile products; Wearing apparel, Dressing & dyeing of fur; Leather & leather products; Wood & wood products; Pulp, paper & paper products; Publishing, printing & reproduction of recorded media; Coke, refined petroleum products & nuclear fuel; Chemicals, chemical products & man-made fibres; Rubber & plastic products; Other non-metallic mineral products; Basic metals; Fabricated metal products except machinery & equipment; Machinery & equipment not else classified; Office machinery & equipment; Electrical machinery and apparatus not else classified; Radio, television & communication equipment and apparatus; Medical, precision & optical instruments, Watches & clocks; Motor vehicles, Trailers & semi-trailers; Other transport equipment; Manufacturing not else classified; Utilities, Construction; Motor trades; Wholesale; Retail; Hotels & catering; Transport; Post and telecommunications; Finance; Property & business services; Education; Health; Public administration & other services.

[§§§§] Aerospace, Agriculture/food, Automotive, Biotechnology, Business services, Ceramics, Chemicals, Civil Engineering and construction, Clothing, Clothing/ linen/ carpet, Computer related services, Concrete and plaster products, Construction, Construction and construction products, Consultancy / business services, Creative industries, Direct marketing services, Domestic appliance manufacture, Electronics, Electrical industrial equipment, Environmental industries, Finance, Footwear manufacture, Furniture manufacture, Household textiles and clothing, Industrial machinery, Information / communication technologies, Instrumentation, Jewellery, Knitwear, Leather goods, Machinery and industrial equipment, Marine engineering technology, Medical / surgical equipment, Metal processing, ship repair and industrial equipment, Metals, Motor sport, Nuclear fuel processing, Oil and gas, Oil / gas / offshore services, Opto-electronics, Paper and paperboard, Perfume / toiletries / essential oils, Pharmaceuticals, Pharmaceuticals / biotechnology, Plastics, Printing and paper, Property and real estate, Quarrying equipment, Research and development activities, Rubber products / tyres, Shipbuilding, Shipbuilding and engineering, Textiles, Tourism, Toys and games, Travel / entertainment/ tourism, Whisky, Wood / furniture, Wood and paper products, Woollens.

- For the purpose of this analysis we developed a comprehensive database using secondary sources. The database comprises of 188,970 firms registered in the region. This represents 92% of the statistically registered firms in the region as per the end of 2002. (Office for National Statistics, 2004). As our database represents well the statistically registered population of firms in the region, we were able to use all firm data related to activities and operations, employment and revenue. The overlap between the figure for total employment in our database and the statistically registered employment for 2002 is 80%. With this database and the multi-stage methodology for cluster mapping we identified 31 clusters that specialise in distinctive sets of economic activities.

- On the basis of the 31 regional clusters that we identified in the region, we applied methodology for cluster analysis that enabled us to explore inter-industry relationships within and across clusters, and to draw maps of inter-industry relationships that constitute the core structure of each cluster. This methodology is based on the application of techniques for network analysis that reveal structural compositions based on strength of particular relations.

- Inter-industry connectivity in the context of this report means synergies captured by firms by horizontal and vertical diversification across selected industries. Two industries declared by a firm as areas of operations, are connected via the firm, and this is interpreted as evidence of a value-link between the two industries that reveals aspects of the value chain in a cluster.

- Each individual cluster map is designed to represent in full the most significant inter-industry relations that exist as part of the diversification portfolio of cluster-member firms. The percentage of represented ties as a threshold is selected specifically according to the cluster size and the intensity of inter-industry links. In most cases, the core structure of a cluster includes pairs of industries that are connected by at least 2-3% of the population of firms in the portfolio of operations, and hence, represent a pattern which we interpret as evidence of synergy from interconnected operations across industries.

- It is evident from the cluster maps, that each cluster is a unique bundle of industries in unique configurations drawn by individual firms' strategic decisions to diversify. The cluster structure also demonstrates the effect from 'attractive' industries as areas of operation and as a source of revenue. Comparisons of these maps show that although components and segments represent in general related diversification, the structure of individual clusters discloses

unrelated diversification as well. Although the intention was to reveal the value chains that drive inter-industry links in individual clusters, the inter-industry agglomerations and relations show a variety of configurations that are all related to the main cluster activity. The cluster maps show also real inter-industry agglomerations that diverge significantly from the statistical categories established for monitoring of economic activities. They are also substantially different from the clusters identified by the DTI report (2001), as they represent the entire regional economy, rather than unique peaks in employment of groups of firms.

- The multi-stage cluster methodology also enabled us to develop a database of the cluster membership of firms in the region that subsequently assisted in comparative analysis of clusters. Graph 1 compares all clusters in the region according to their size or the number of registered firms in them. The largest cluster containing a fifth of the entire population of firms in the region is 'investment, business, and management consulting services' (20.3%). It is followed by the cluster 'miscellaneous services' (16.3%), which has very fragmented structure of autonomous parts, and by 'software and computer services' (12.7%).

- The size of a cluster, in terms of number of registered firms, is not always evidence of its impact on the regional economy. Table 2 demonstrates that the clusters that are the largest contributors to employment in the region are 'investment, business, and management consulting' (34%) – as expected, but followed by 'industrial machinery, ICT equipment and metal products' (7%), and 'food processing' with 6% of the regional employment. All other clusters contribute between 1% and 4% of the regional employment independently of their size. The clusters with the largest average number of employees per firm are: 'ultradiversified' (2,676 average employees per firm – see Table 2.), 'utilities' (1,008 average employees per firm), 'food processing, beverages, and tobacco' (724 average employees per firm), 'agriculture and farming' (678 average employees per firm), and 'pharmaceuticals' (671 average employees per firm). The clusters with the lowest average employees per firm in the region are: 'non-classifies establishments' (mean 43), 'real estate' (mean 49), 'finance' (mean 58), 'software and computer services' (mean 75), and 'construction' (mean 94).

- Regarding the contribution of revenue to the region, the largest contributors are: 'investment, business and management consulting services' (31%), 'industrial machinery, ICT equipment and metal products' (8%), 'motor sport, automotive trade and repair' (7%), 'utilities' (6%), and wholesale trade' (6%). The rest of the clusters contribute between 0.5% and 5% of the regional revenue (Table 2.). If we look at the mean for each cluster, or the average revenue per

firm in each cluster, than the clusters with the largest revenue contributing firms are: 'utilities' (316,772 th US$), 'oil and gas extraction, refining and mining' (149,347 th US$), 'pharmaceuticals' (112,108 th US$), 'food processing, beverages, and tobacco' (61,838 th US$), and 'chemicals and allied products' (45,072 th US$).

- One of the most valuable aspects of the selected research approach is that it deals with the entire regional population of firms and all regional clusters. This allows sophisticated analysis of the inter-industry and inter-cluster relations on a larger scale, using network analytical techniques. Map 32 displays all clusters in the region with their industry codes that constitute the core structure of each cluster. The dense network on this map displays all clusters in the region with their core industry portfolio at 10% strength of ties. Although most industries gravitate towards a particular cluster centre, there are a number of industries that are situated as a bridge between cluster activities. We call these bridges connectivity codes, and we have described them at 13% strength of ties (Table 3. and Map 34.). All maps from Map 32 to Map 34 are produced with network analysis of the relations between clusters, where inter-cluster connectivity is calculated by the shared industry codes reported by at least 20 firms in the region. Variation in the strength of tie between 10% and 13% produces structural configurations with different density, where increase in percentage corresponds with relaxation of the cut point for strength of ties and allows more connectivity codes to emerge on the structural map (Map. 34.).

- Due to the large number of industries on Map 32., we have transformed it into six separate segments that display different parts of the regional inter-cluster network. All segments of the regional inter-cluster network are calculated on the basis of 10% strength of ties, in order to select the most significant connections. *Segment A* shows the link between the 'marine technologies' and the 'transportation services' clusters, which comprises of two industries: generic transportation services (SIC 4789), and administration of transportation services (SIC 9621) (Map 32, *Segment A.*). The connection between 'transportation services' and 'trucking and warehousing' is via three industry codes for specialised trucking services, which are shared between the two clusters (SIC 4212, 4213, 4231). *Segment A* also displays a bridge between 'marine technologies' and 'utilities', consisting of water transportation services (SIC 4499). A unique feature on the same Map is the multi-cluster bridge of regulation and administration of transportation (SIC 9621) that connects 'marine technologies', 'transportation services', and 'non-classified establishments'.

Graph 1. The cluster structure of the regional economy in the South East of England

CLUSTERS OF FIRMS BY US SIC CODES

- Agriculture & Farming - 0,9%
- Food Processing, Beverages & Tobacco - 0,7%
- Oil & Gas Extraction, Refining & Mining - 0,2%
- Construction - 7,8%
- Chemicals & Allied Products - 0,6%
- Pharmaceuticals - 0,2%
- Industrial Machinery, ICT Equipment & Metal Products - 2,9%
- Instrumentation - 0,5%
- R&D - 2,1%
- Transport Equipment, Aircraft & Space Vehicles - 0.2%
- Marine Technologies Equipment & Services - 0,3%
- Motor Sport, Automotive Trade & Repair - 1,8%
- Furniture, Fixture & Wood Products - 0,7%
- Miscelleneous Consumer Products - 1,1%
- Utilities - 0,2%
- Communication Services - 0,8%
- Software & Computer Services - 12,7%
- Publishing - 1,6%
- Finance - 1,0%
- Real Estate - 10,0%
- Investment, Business & Management Consulting Services - 20,3%
- Transportation Services - 1,9%
- Trucking & Warehousing - 0,2%
- Wholesale Trade - 3,2%
- Retail - 3,2%
- Hotels & Restaurants - 1,6%
- Amusement & Recreation Services -2,6%
- Health Services - 0,8%
- Miscelleneous Services - 16,3%
- Non-clasified Establishments - 2,5%
- Ultra diversified - 0,2%
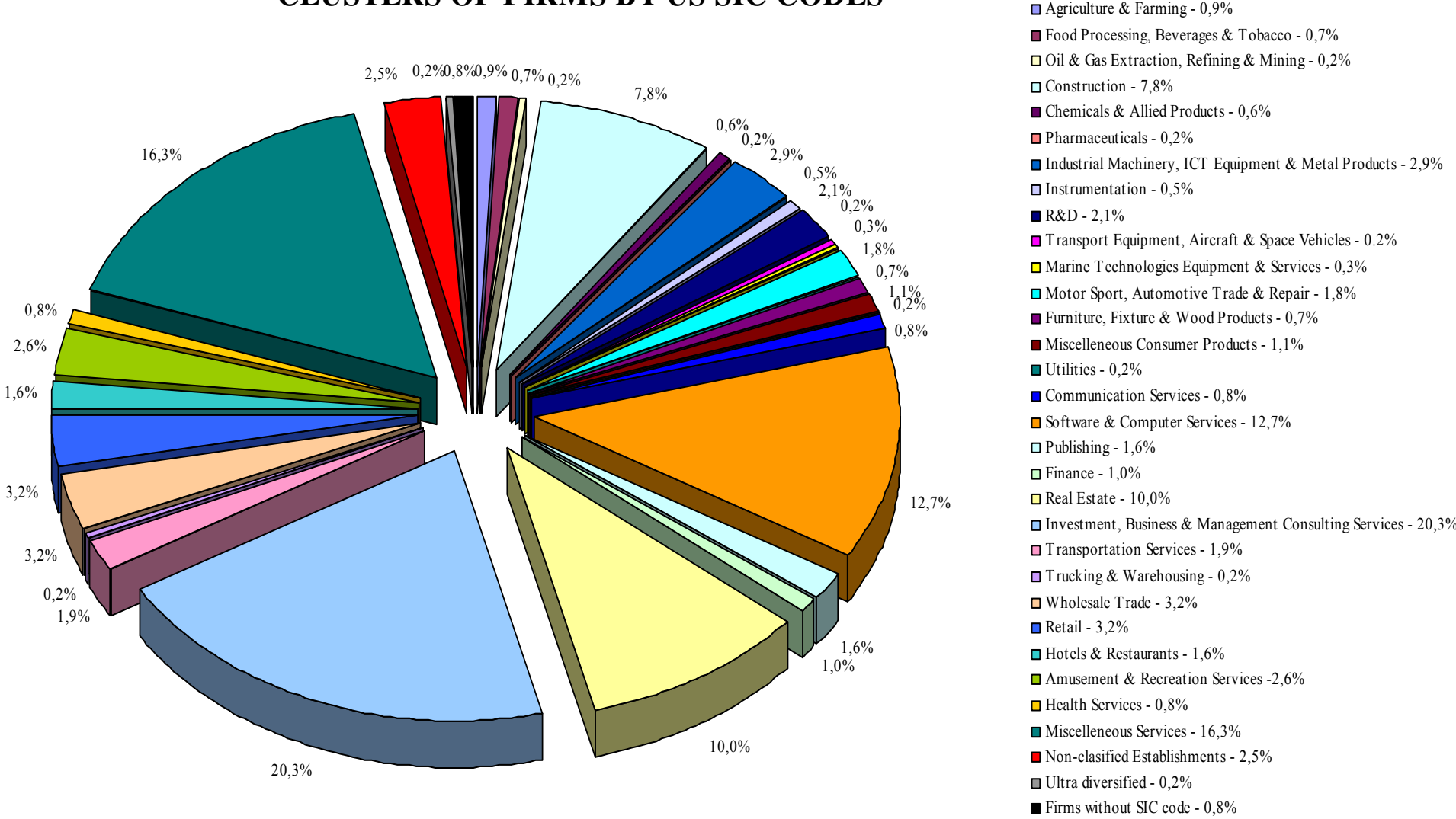- Firms without SIC code - 0,8%

Table 2. Cluster demography – distribution of employment and revenue per cluster[*****]

Clusters	Firms	%	Rev	% R	ReplR	% rR	MeanR	Empl	% E	ReplE	% rE	MeanE
Agriculture & Farming	1 769	0,9%	3 745 991	0,6%	631	35,7%	5 937	104 396	3,3%	154	8,7%	678
Food Processing, Beverages & Tobacco	1 369	0,7%	30 919 034	4,6%	500	36,5%	61 838	180 974	5,7%	250	18,3%	724
Construction	14 676	7,8%	16 133 001	2,4%	4 678	31,9%	3 449	81 850	2,6%	875	6,0%	94
Real Estate	18 897	10,0%	5 396 258	0,8%	6 483	34,3%	832	25 969	0,8%	525	2,8%	49
Furniture, Fixture & Wood Products	1 254	0,7%	1 940 675	0,3%	383	30,5%	5 067	12 889	0,4%	147	11,7%	88
Miscellaneous Consumer Products	2 042	1,1%	9 784 854	1,4%	635	31,1%	15 409	60 255	1,9%	279	13,7%	216
Utilities	305	0,2%	40 863 524	6,0%	129	42,3%	316 772	70 531	2,2%	70	23,0%	1 008
Communication Services	1 540	0,8%	15 572 010	2,3%	589	38,2%	26 438	55 141	1,7%	163	10,6%	338
Miscellaneous Services	30 850	16,3%	17 318 575	2,6%	4 044	13,1%	4 283	115 381	3,7%	1 046	3,4%	110
Health Services	1 473	0,8%	1 424 708	0,2%	467	31,7%	3 051	30 085	1,0%	161	10,9%	187
Pharmaceuticals	285	0,2%	12 780 275	1,9%	114	40,0%	112 108	46 273	1,5%	69	24,2%	671
Chemicals & Allied Products	1 116	0,6%	19 110 496	2,8%	424	38,0%	45 072	70 850	2,2%	277	24,8%	256

[*****] The definitions of the indicators in this table are as follows:

Firms = Number of firms in cluster

% = % of firms in cluster from the total population

Rev = Total revenue per cluster

% R = % of the total cluster revenue from the total population revenue

ReplR = Number of firms replied with revenue data

%rR = % of firms in each cluster replied with revenue data

MeanR = Mean revenue (average revenue per replied firm)

Empl = Total employment per cluster

% E = % of the total cluster employment from the total population employment

ReplE = Number of firms replied with employment data

%rE = % of firms in each cluster replied with employment data

MeanE = Mean employment (average employment per replied firm)

Clusters - `cont	Firms	%	Rev	% R	ReplR	% rR	MeanR	Empl	% E	ReplE	% rE	MeanE
Oil & Gas Extraction, Refining & Mining	355	0,2%	21 057 938	3,1%	141	39,7%	149 347	17 226	0,5%	43	12,1%	401
Motor Sport, Automotive Trade & Repair	3 437	1,8%	45 228 677	6,7%	1 290	37,5%	35 061	80 598	2,6%	490	14,3%	164
Transportation Services	3 583	1,9%	15 372 020	2,3%	1 188	33,2%	12 939	71 085	2,3%	328	9,2%	217
Trucking & Warehousing	425	0,2%	3 884 512	0,6%	158	37,2%	24 586	14 387	0,5%	70	16,5%	206
Transport Equipment, Aircraft & Space Vehicles	356	0,2%	3 172 785	0,5%	147	41,3%	21 584	26 765	0,8%	66	18,5%	406
Marine Technologies Equipment & Services	586	0,3%	3 238 289	0,5%	188	32,1%	17 225	22 987	0,7%	65	11,1%	354
Industrial Machinery, ICT Equipment & Metal Products	5 406	2,9%	56 259 888	8,3%	1 953	36,1%	28 807	216 617	6,9%	995	18,4%	218
Software & Computer Services	23 993	12,7%	23 083 224	3,4%	9 416	39,2%	2 451	114 569	3,6%	1 535	6,4%	75
Instrumentation	1 027	0,5%	3 107 880	0,5%	368	35,8%	8 445	20 639	0,7%	176	17,1%	117
R&D	3 948	2,1%	6 819 695	1,0%	1 410	35,7%	4 837	55 009	1,7%	282	7,1%	195
Investment, Business & Management Consulting Services	38 406	20,3%	210 261 919	31,1%	12 061	31,4%	17 433	1 075 729	34,0%	2 449	6,4%	439
Finance	1 912	1,0%	5 478 954	0,8%	775	40,5%	7 070	15 949	0,5%	273	14,3%	58
Publishing	3 015	1,6%	10 541 433	1,6%	1 021	33,9%	10 325	71 430	2,3%	379	12,6%	188
Wholesale Trade	6 113	3,2%	43 314 554	6,4%	2 046	33,5%	21 170	122 762	3,9%	868	14,2%	141
Retail	6 133	3,2%	26 570 237	3,9%	1 944	31,7%	13 668	128 120	4,1%	391	6,4%	328
Hotels & Restaurants	3 100	1,6%	16 022 586	2,4%	1 171	37,8%	13 683	126 469	4,0%	396	12,8%	319
Amusement & Recreation Services	4 988	2,6%	2 367 514	0,4%	1 577	31,6%	1 501	18 541	0,6%	334	6,7%	56
Non-classified Establishments	4 700	2,5%	404 764	0,1%	354	7,5%	1 143	4 146	0,1%	96	2,0%	43
Ultra diversified	374	0,2%	4 833 770	0,7%	146	39,0%	33 108	101 682	3,2%	38	10,2%	2 676
Firms without SIC code	1 537	0,8%	195 698	0,0%	304	19,8%	643	1 713	0,1%	36	2,3%	48
Total	188 970	100%	676 205 738	100%	56 735	30,0%	11 919	3 161 017	100%	13 326	7,1%	237

Map 32. Inter-cluster relations established by more than 20 firms which have declared an industry code (at 10% strength of ties, delete isolates)
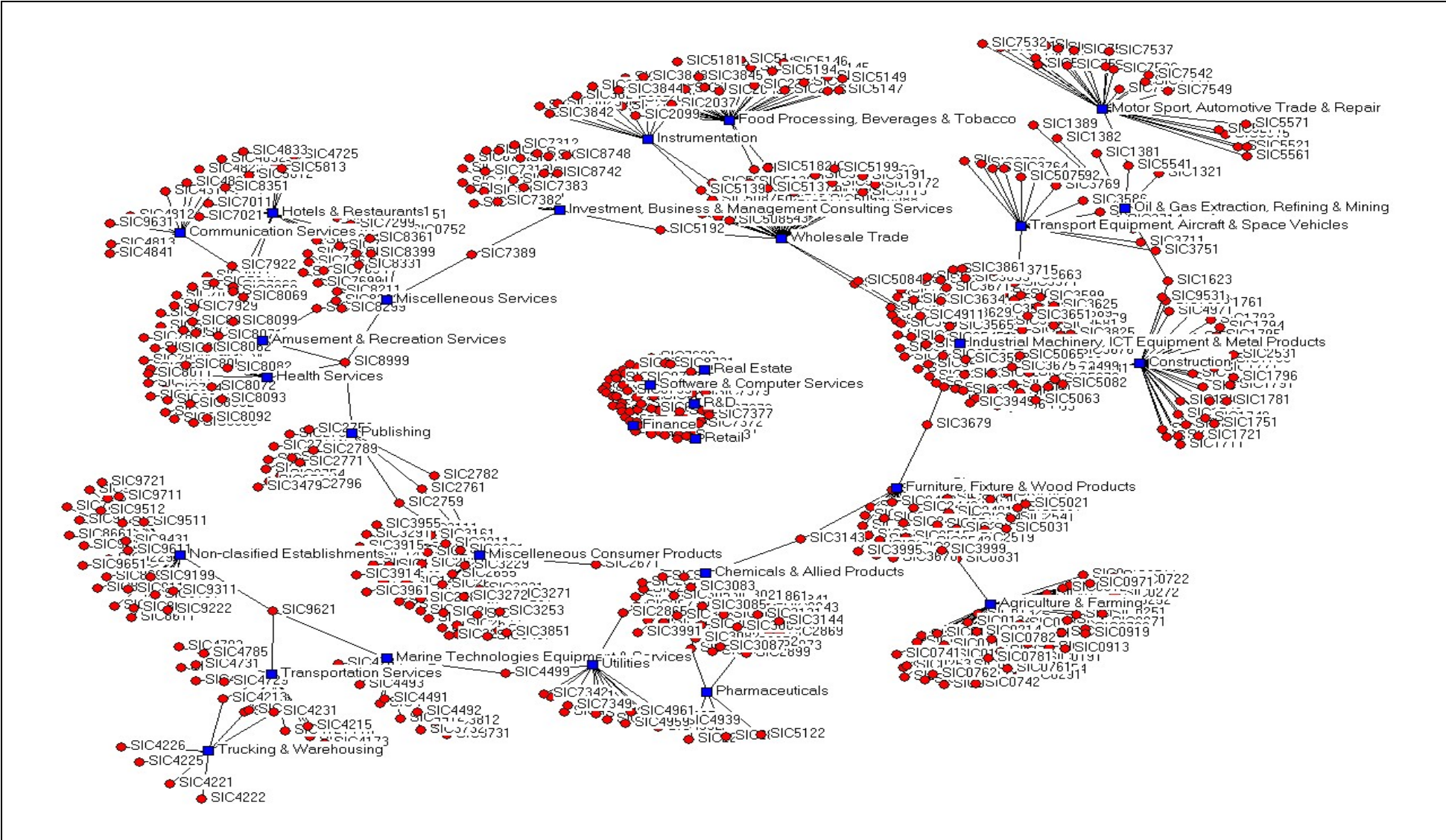
Map 32. Inter-cluster relations established by more than 20 firms which have declared an industry code (at 10% strength of ties, delete isolates)
Segment A: **Interconnected Utilities, Marine technologies, Transportation services, Trucking & warehousing, and Non-classified establishments**
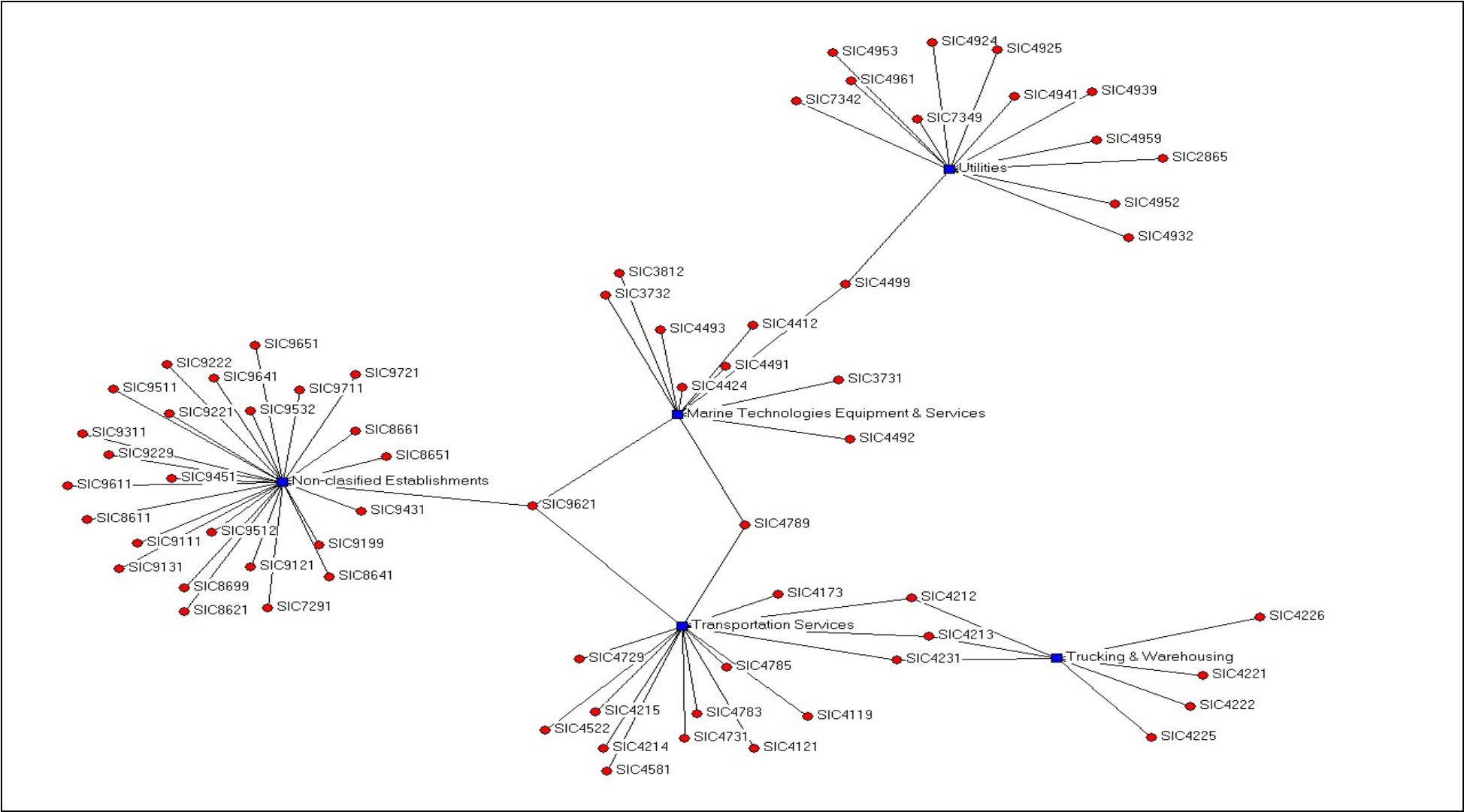
Map 32. Inter-cluster relations established by more than 20 firms which have declared an industry code (at 10% strength of ties, delete isolates)
Segment B: **Interconnected Pharmaceuticals, Chemicals, Utilities, Furniture & fixture, Agriculture & farming, and Miscellaneous products**

Map 32. Inter-cluster relations established by more than 20 firms which have declared an industry code (at 10% strength of ties, delete isolates)
Segment C: **Interconnected Industrial machinery & ICT equipment, Transport equipment & aircraft, Construction, Oil & gas, and Motor trade**

Map 32. Inter-cluster relations established by more than 20 firms which have declared an industry code (at 10% strength of ties, delete isolates)
Segment D: **Interconnected Communication services, Amusement & recreation, Publishing, Miscellaneous services, Hotels & restaurants & Health services**

Map 32. Inter-cluster relations established by more than 20 firms which have declared an industry code (at 10% strength of ties, delete isolates)
Segment E: **Interconnected Investment, business & management consulting services, Wholesale trade, Instrumentation, and Food processing**

Map 32. Inter-cluster relations established by more than 20 firms which have declared an industry code (at 10% strength of ties, delete isolates)

Segment F: **Unconnected clusters of Software & computer services, R&D, Real estate, Finance and Retail**

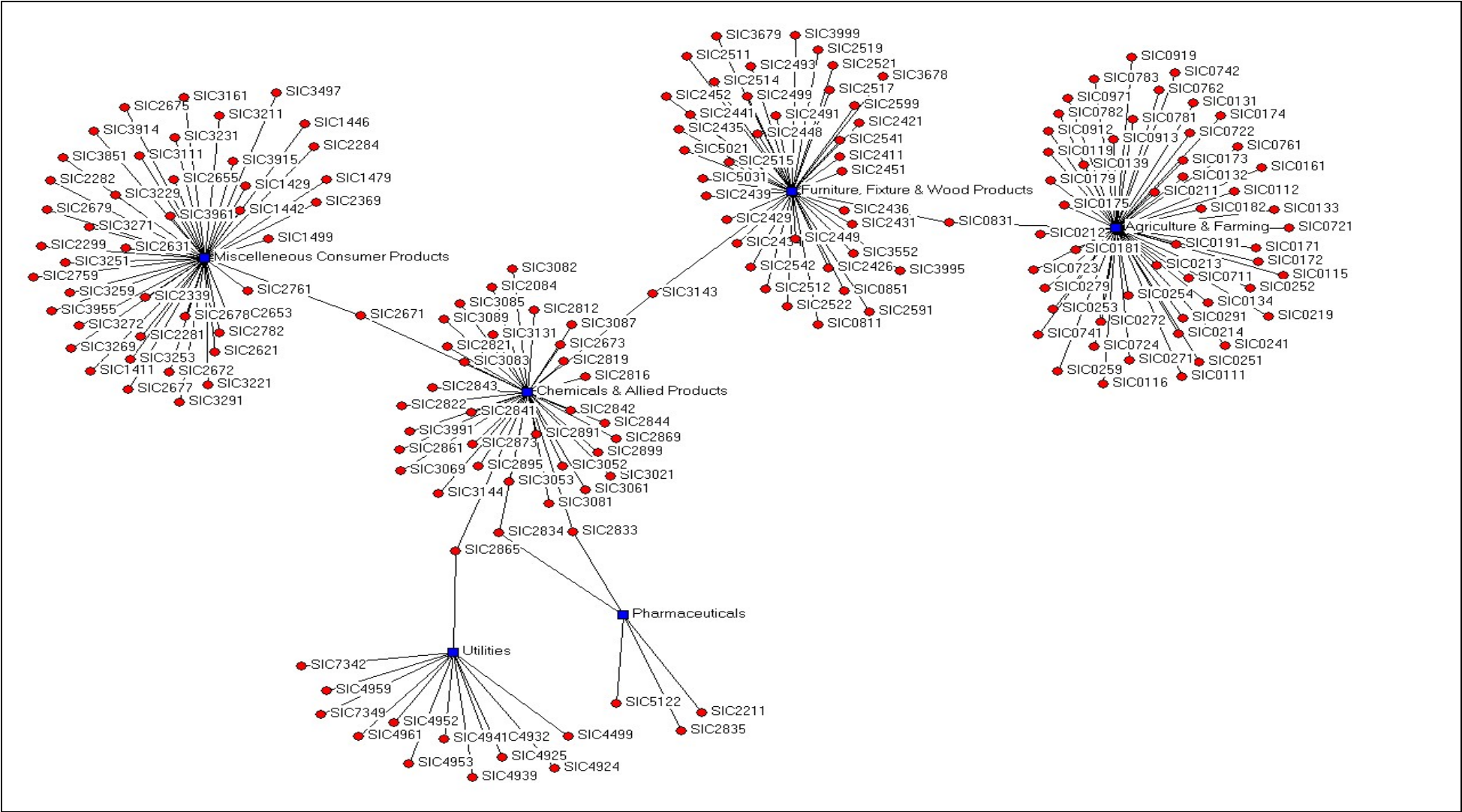**Map 33. Inter-cluster relations established by more than 20 firms which have declared an industry code (at 10% strength of ties, delete isolates and pendants)**

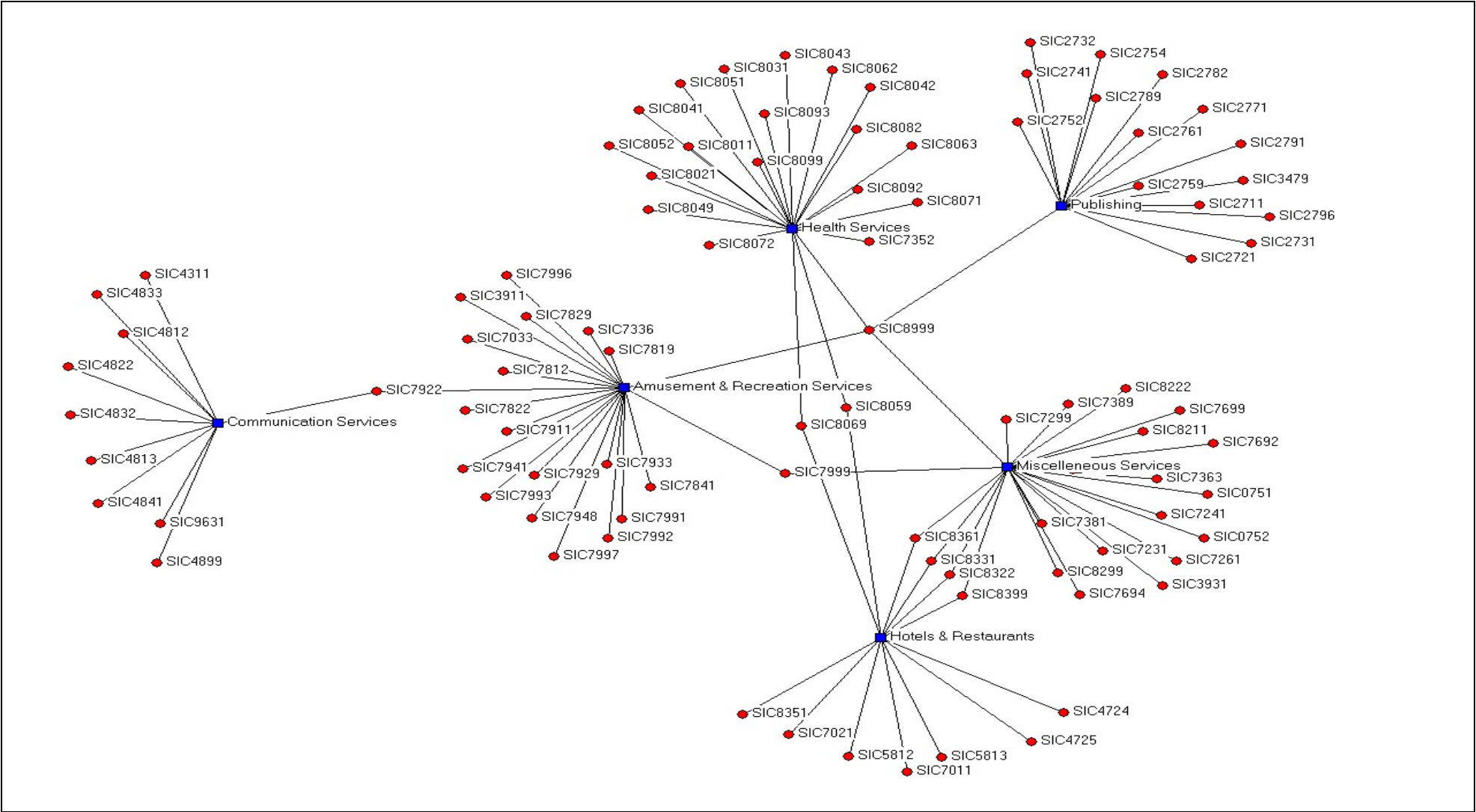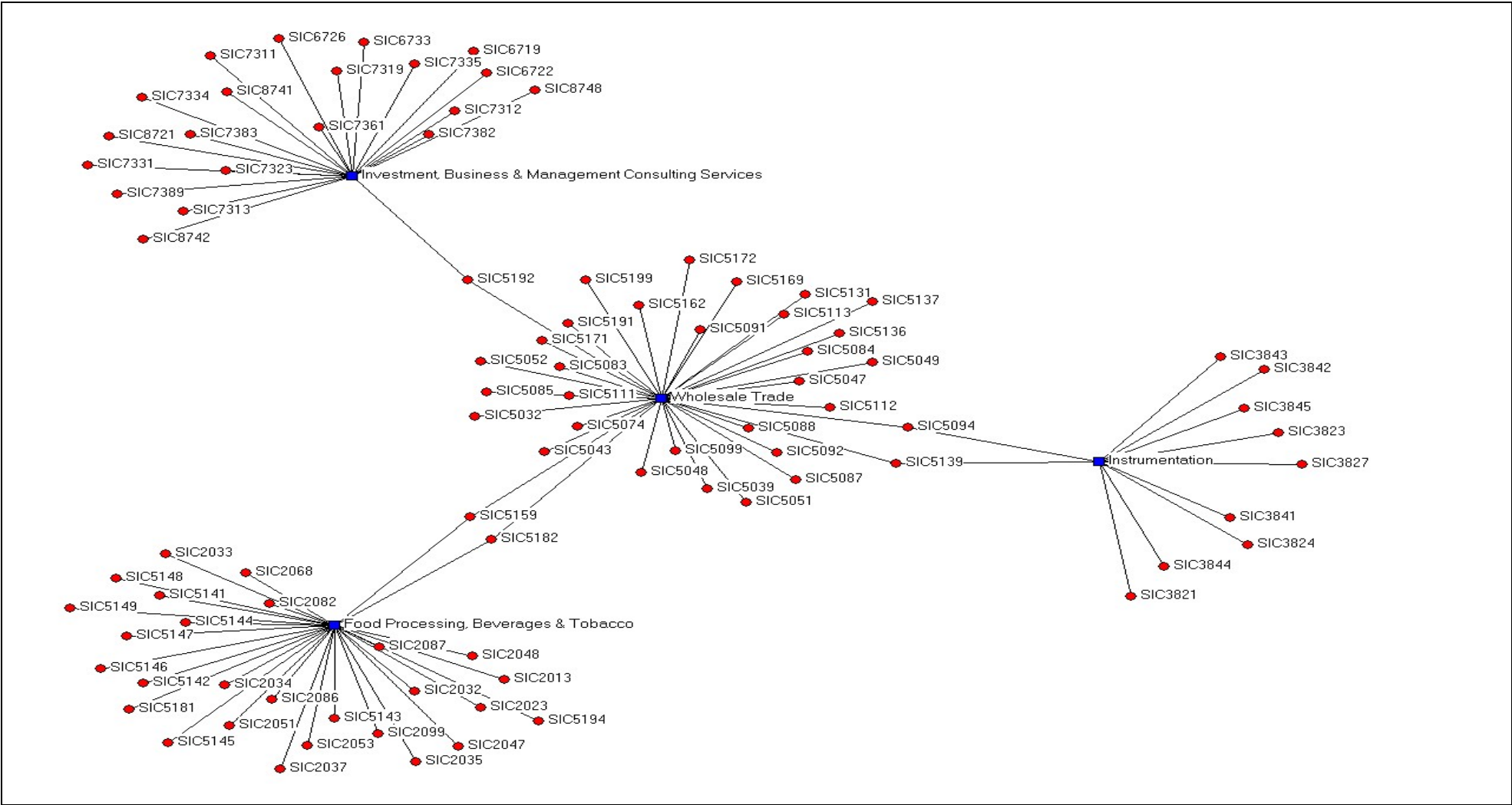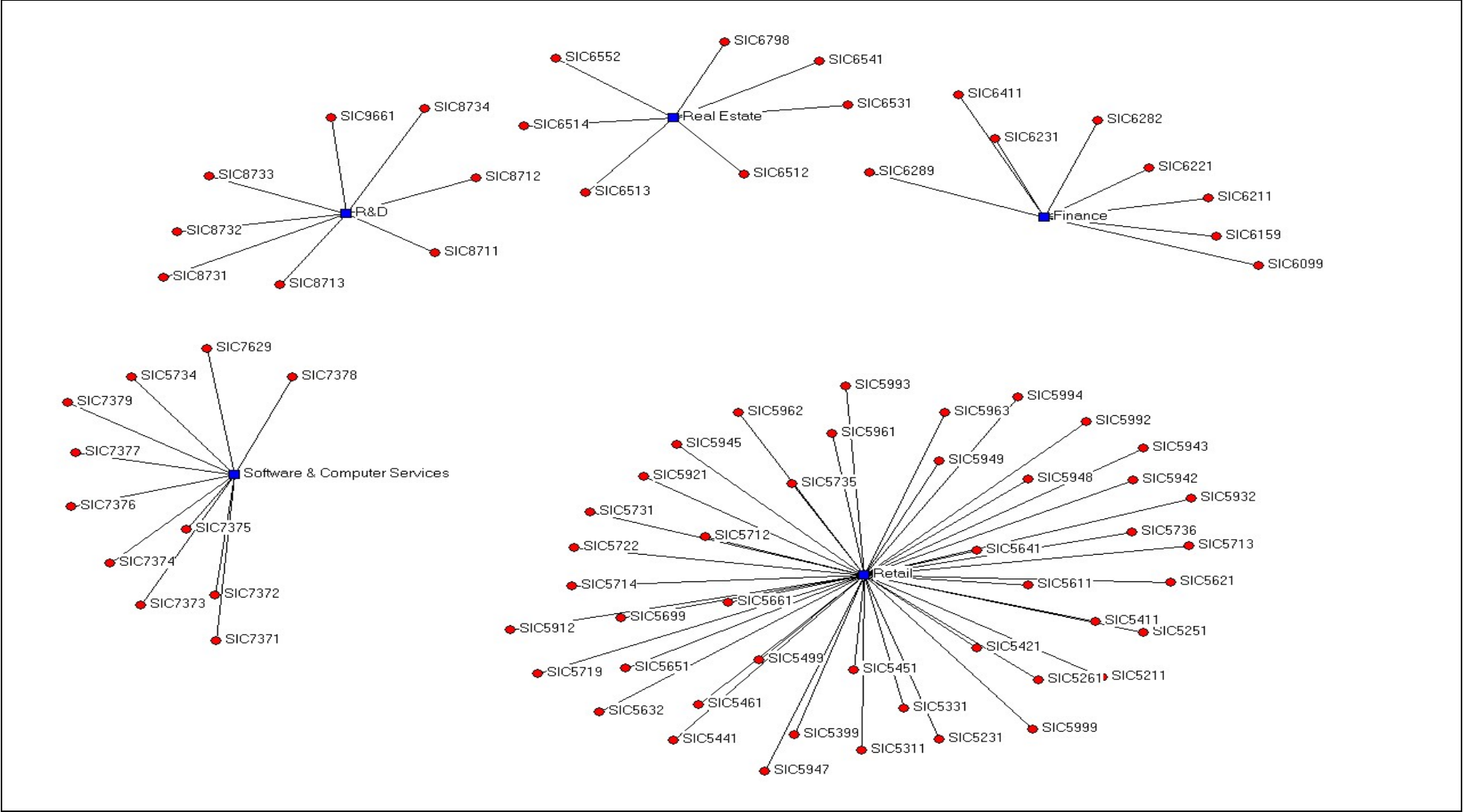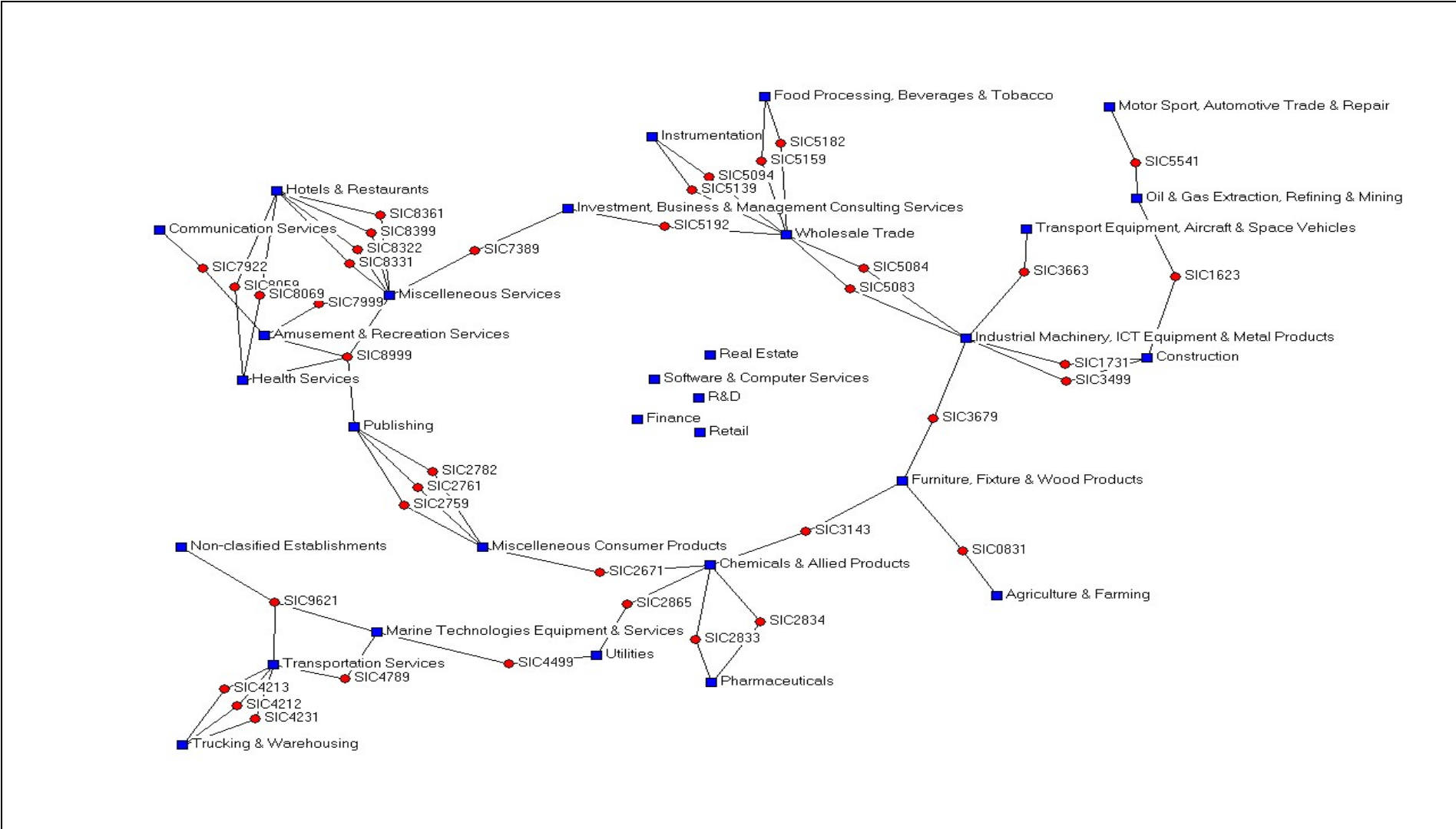**Map 34. Inter-cluster relations established by more than 20 firms which have declared an industry code (at 13% strength of ties, delete isolates and pendants)**
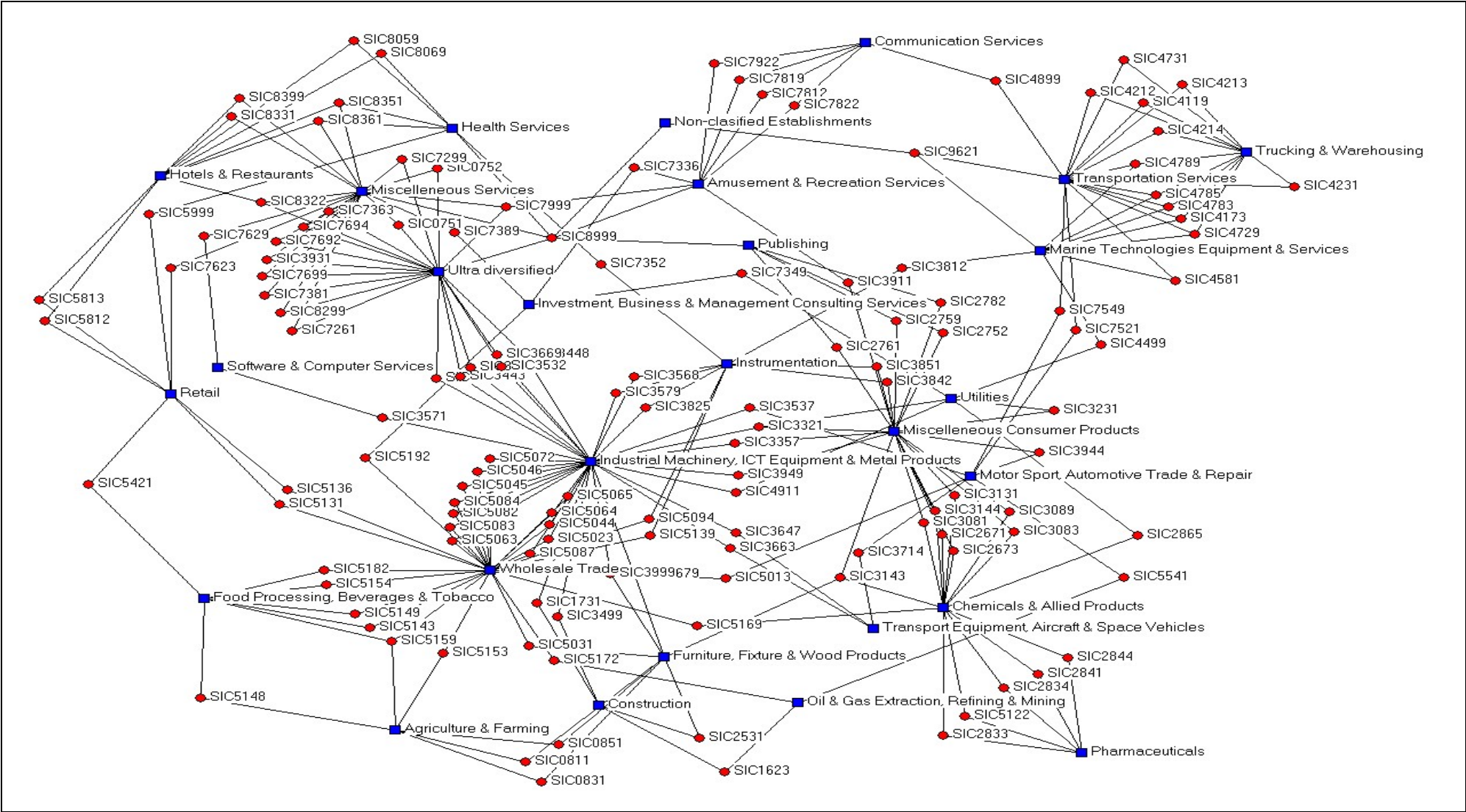
- *Segment B* of Map 32. displays connectivity between another set of clusters. 'Chemicals and allied products' is the most connected cluster in this set, and it shares industry codes with four other clusters. It shares paper and packaging code (SIC 2671) with the cluster of 'miscellaneous products'; shares activities in industrial and organic chemicals (SIC 2865) with the 'utilities' cluster; shares activities in leather products (SIC 3143) with firms from the 'furniture and fixture' cluster; and shares two industry codes with the pharmaceuticals - pharmaceutical preparation (SIC 2834), and medicinals and botanicals (SIC 2833). All these shared industry codes mean that the products in each of the shared categories are inputs to and parts of different value chains that run through different clusters. In addition, the cluster 'furniture & wood products' is connected to the cluster 'agriculture and farming' via shared activities in forest products (SIC 0831).

- *Segment C* of Map 32 displays the relations between five different clusters. The 'motor sports and automotive trade' and the 'oil and gas' clusters share activities in running gasoline stations (SIC 5541). The 'construction' and the 'oil and gas' clusters share activities in construction of utility lines (SIC 1623). On the other hand, the 'construction' cluster shares two common activities with the 'industrial machinery, ICT equipment and metal products' cluster. These are: one generic code for fabricated metal products (SIC 3499), and the industry code for special trade contractors for electrical work (SIC 1731). Further, the 'industrial machinery and ICT equipment' cluster shares activity with the 'transport equipment' cluster in the area of communication equipment (SIC 3663).

- *Segment D* of Map 32 shows complex relations between six clusters. A central element if this configuration is the industry code for services (SIC 8999), which is shared by four clusters: 'publishing', 'health services', 'hotels and restaurants', and 'amusement and recreation'. This is a very generic code and it is difficult to identify what business activity exactly stands behind, and whether it involves similar activities in the four connected clusters. Another generic industry code is SIC 7999 for amusement and recreation activities, which is shared between the 'amusement and recreating' cluster and the 'miscellaneous services' cluster. The two clusters 'miscellaneous services' and 'hotels and restaurants' share four industry codes as follows: residential care (SIC 8361); job training (SIC 8331); individual and family services (SIC 8322); social services (SIC 8399). The two clusters 'health services' and 'hotels and restaurants' share two industry areas – nursing homes and personal care (SIC 8059) and specialty hospitals (SIC

117

8069). The clusters 'communication services' and 'amusement and recreation' also share an area of common activities, and this is theatrical production (SIC 7922).

- *Segment E* of Map 32 displays the position that 'wholesale trade' cluster has in relation to three other clusters. It shares two industry codes with 'instrumentation': wholesale trade of jewellery (SIC 5094), and of footwear (SIC 5139). This unrelated diversification can not be explained with any value-chain activities, and requires further investigation. The cluster shares two main industry codes with the 'food processing' cluster, and they are wholesale trade of farm products and raw materials (SIC 5159), and of wine and distilled beverages (SIC 5182). Finally, it shares one industry code with the cluster 'investment, business and management services', and this is wholesale trade of books, periodicals and newspapers (SIC5192).

- *Segment F* on Map 32 shows five clusters that are not connected to any other cluster in the region. On the original diagram on Map 32 they are displayed in the middle of the map. This can be interpreted as evidence that firms in these clusters diversify within the main cluster activities, and do not diversify across unrelated business areas and across clusters. These stand alone clusters are: 'software and computer industry', 'R&D', 'real estate', 'finance', and 'retail'.

- Map 33 displays the inter-cluster connectivity in the region at the same level of strength of ties (10%) as for the various maps in Map32, *Segments A-F*. However, it does not give details of the industries that are connected to only one cluster. These industries in the UCINET software are labelled 'pendants', and are deleted from the display. The map demonstrates the interconnectivity established at the level of the regional economy that represents inter-linked value chains, where particular activity areas have developed generic products and technologies with application to multiple value chains. Map 33 displays the strongest links between clusters in the South East of England.

- Map 34 is similar, but displays ties with strength at 13%, or at a lower cut-point. On this map we have cleared both the industries connected to one cluster only (pendants) and unconnected clusters (isolates – or the clusters in Map 32, *Segment F.*). What is evident from this map is that the inter-cluster connectivity is substantial and as more we reduce the threshold of strength of ties, more we increase the presence of weaker ties on the map, and more we reveal shared areas

of operation where firms are exposed to competition from multiple clusters. The multiple linkages displayed on Map 34 are where firms can seek market application of their products and technologies in multiple value chains. All industry codes that are shared between clusters from this Map are labelled 'connectivity codes', and are listed in Table 3.

- The connectivity codes that link clusters are described in detail in Table 3. Overall Table 3 compares all clusters according to the total number of codes (or the scope of diversification of firms for each particular cluster), the average number of codes per firm within each cluster, the percentage of firms in each cluster that have declared only one 3-digit code, and the number of structural codes in each cluster that are displayed in the structural maps 1-31. In the list of connectivity codes we have distinguished between industry codes that are shared between two clusters only, and industry codes that are shared by more than two clusters, or areas that attract firms' activities in multiple clusters (highlighted in bold). The total number of industry codes, or areas of business activities in the region, is 951. The average scope of diversification of firms in the region is 6 industry codes, and the clusters, with the widest scope of diversification of firms are: 'multi-diversified' (with average diversification 22 industries per firm), followed by 'health services' (with average diversification 15 industries per firm), and 'wholesale trade' (with average diversification 11 industries per firm). Overall 82% of all industries active in the region, or 776 industry codes are included in the individual structural maps 1-31.

- Table 3. lists the connectivity codes for all industries that link clusters in the region at 13% strength of ties, which corresponds with Map 34. If we change the threshold, or the cut point below which we consider the strength of ties insufficient, this has a direct impact on the number of ties and the structural configuration that emerges between clusters and industries in the region. The two maps 33 and 34 exhibit very well this specific feature of network analysis. As the criteria for thresholds and cut points are relaxed (from 10% to 13%), this allows more relations between industries and clusters to be exhibited, and the increased connectivity within the regional economy shows a modified set of inter-cluster relations. Different levels of richness and depth of relational data reveal different aspects of the inter-cluster relations, where more industry codes emerge as multi-cluster bridges. Connectivity codes that link multiple clusters in Map 34. are described in details in Table 3.

Table 3. Cluster demography – industry representation and inter-cluster connectivity

Cluster	Total number of codes	Average number of codes	% of firms with 3-digit SIC only	Number of structural codes[†††††]	Connectivity codes[‡‡‡‡‡]
Agriculture & farming	293	8	0%	51	Food processing, beverages & tobacco (SIC5148-Wholesale Trade-Fresh fruits and vegetables) Furniture, fixture & wood products (SIC0811-Forestry-Timber tracts, SIC0831-Forest products, SIC0851–Forestry services) Wholesale trade (SIC5153-Wholesale Trade-Grain and field beans) **Food processing and Wholesale trade (SIC5159-Wholesale Trade-Farm-product raw materials)[§§§§§]**
Food processing, beverages & tobacco	157	4	9%	26	Agriculture & farming (SIC5148-Wholesale Trade-Fresh fruits & vegetables) Wholesale trade (SIC5143-Wholesale Trade-Dairy products, SIC5149-Wholesale Trade-Groceries & related products, SIC5154-Wholesale Trade-Livestock, SIC5182–Wholesale Trade-Wine & distilled beverages) Retail (SIC5421-Meat and fish markets) **Agriculture & farming and Wholesale trade (SIC5159-Wholesale Trade-Farm-product raw materials)**
Construction	375	7	0%	36	Oil & gas (SIC1623–Heavy Construction-Water, sewer, and utility lines) Industrial machinery & ICT (SIC1731-Special Trade Contractors-Electrical work, SIC3499–Fabricated metal products) Furniture, fixture & wood products (SIC2531-Public building & related furniture)
Real estate	275	4	12%	16	
Furniture, fixture & wood products	217	9	0%	30	Agriculture & farming (SIC0811-Forestry-Timber tracts, SIC0831-Forest products, SIC0851-Forestry services) Construction (SIC2531-Public building & related furniture) Industrial machinery & ICT (SIC3679-Electronic components, SIC3999-Manufacturing industries) Wholesale trade (SIC5031-Wholesale Trade-Lumber, plywood, and millwork) **Chemical & allied products and Miscellaneous consumer products (SIC3143-Leather & Leather Products-Men's footwear, except athletic)**
Miscellaneous consumer products	295	2	59%	26	Chemical & allied products (SIC2671-Paper coated & laminated, packaging, SIC2673-Bags: plastics, laminated, & coated, SIC3081-Unsupported plastics film & sheet, SIC3083-Laminated plastics plate & sheet, SIC3089-Plastics products, SIC3131- Footwear cut stock, SIC3144- Women's footwear, except athletic) Industrial machinery & ICT (SIC3357- Nonferrous wiredrawing & insulating, SIC3949- Miscellaneous Manufacturing Industries-Sporting & athletic goods) Instrumentation (SIC3842-Surgical appliances and supplies, SIC3851-Ophthalmic goods) Utilities (SIC3231- Primary Metal Industries-Gray and ductile iron foundries) Motor trade (SIC3944-Games, toys, and children's vehicles) Publishing (SIC2752-Commercial printing, lithographic, SIC2759-Commercial printing, SIC2761-Manifold business forms, SIC2782-Blank-books and loose-leaf binders) Amusement & recreation services (SIC3911-Jewelry, precious metal) **Industrial machinery & ICT and Utilities (SIC3321-Iron & Steel Foundries-Gray & ductile iron foundries)** **Chemical & allied products and Furniture, fixture & wood products (SIC3143-Leather & Leather Products-Men's footwear, except athletic)**
Utilities	37	2	27%	14	Chemical & allied products (SIC2865-Industrial Organic Chemicals-Cyclic crudes & intermediates) Industrial machinery & ICT (SIC4911- Electric services) Marine technologies (SIC4499-Water transportation services) Miscellaneous consumer products (SIC3231- Primary Metal Industries-Gray and ductile iron foundries) Investment, business & management services (SIC7349-Building maintenance services) **Industrial machinery & ICT and Miscellaneous consumer products (SIC3321-Iron & Steel Foundries-Gray & ductile iron foundries)**

[†††††] *Structural codes* are those codes that constitute the core structure of individual clusters and are displayed on cluster maps 1-31.

[‡‡‡‡‡] *Connectivity codes* are industry codes that act as bridges between value-added activities in individual clusters, and are displayed on Map 34.

[§§§§§] Industries in bold connect multiple clusters

Communication services	**142**	**6**	**0%**	**13**	**Transportation services (SIC4899-Communication services)** **Amusement & recreation services (SIC7812-Motion picture & video production, SIC7819-Services allied to motion pictures, SIC7822-Motion picture and tape distribution, SIC7922- Theatrical producers and services)**
Miscellaneous services	335	5	60%	39	Software & computer services (SIC7629-Electrical repair shops) Investment, business & management services (SIC7389-Security systems services) Retail (SIC7623-Refrigeration service and repair) Hotels & restaurants (SIC8331- Social Services-Job training and related services, SIC8399-Social services) Ultra-diversified (SIC0751-Livestock services, exc. veterinary, SIC0752-Animal specialty services, SIC3931-Musical instruments, SIC7261-Funeral service and crematories, SIC7299-Miscellaneous personal services, SIC7363-Business Services-Help supply services, SIC7381-Detective & armoured car services, SIC7692-Welding repair, SIC7694-Armature rewinding shops, SIC7699-Repair services, SIC8299-Schools & educational services) **Amusement & recreation services and Ultra-diversified (SIC7999-Amusement and recreation)** **Hotels & restaurants and Health services (SIC8351-Social Services-Child day care services, SIC8361-Residential care)** **Hotels & restaurants and Ultra-diversified (SIC8322-Individual and family services)** **Publishing, Amusement & recreation services, Health services, Non-classified establishments and Ultra-diversified (SIC8999-Services)**
Health services	277	15	0%	30	Instrumentation (SIC7352-Medical equipment rental) Retail (SIC 5999- Miscellaneous retail stores) Hotels & restaurants (SIC8059-Health Services-Nursing and personal care, SIC8069-Specialty hospitals exc. Psychiatric) **Hotels & restaurants and Miscellaneous services (SIC8351-Social Services-Child day care services, SIC8361-Residential care)** **Publishing, Amusement & recreation services, Miscellaneous services, Non-classified establishments and Ultra-diversified (SIC8999-Services)**
Pharmaceuticals	40	2	0%	9	Chemical & allied products (SIC2833- Drugs-Medicinals & botanicals, SIC2834-Drugs-Pharmaceutical preparations, SIC2841-Soap & other detergents, SIC2844-Toilet preparations, SIC5122-Wholesale Trade-Drugs, proprietaries & sundries)
Chemicals & allied products	218	6	6%	24	Pharmaceuticals (SIC2833-Drugs-Medicinals & botanicals, SIC2834-Drugs-Pharmaceutical preparations, SIC2841-Soap & other detergents, SIC2844-Toilet preparations, SIC5122- Wholesale Trade-Drugs, proprietaries, and sundries) Miscellaneous consumer products (SIC2671-Paper coated & laminated, packaging, SIC2673-Bags: plastics, laminated, & coated, SIC3081-Unsupported plastics film & sheet, SIC3083-Laminated plastics plate & sheet, SIC3089-Plastics products, SIC3131- Footwear cut stock, SIC3144- Women's footwear, except athletic) Utilities (SIC2865-Industrial Organic Chemicals-Cyclic crudes & intermediates) Wholesale trade (SIC5169-Wholesale Trade-Chemicals & allied products) **Furniture, fixture & wood products and Miscellaneous consumer products (SIC3143-Leather & Leather Products-Men's footwear, except athletic)**
Oil & gas extraction, refining & mining"	66	4	5%	8	Construction (SIC1623-Heavy Construction-Water, sewer, & utility lines) Motor sport (SIC5541-Gasoline service stations) Wholesale trade (SIC5172-Wholesale Trade-Petroleum products)
Motor sport, automotive trade & repair	230	8	0%	24	Oil & gas (SIC5541-Gasoline service stations) Industrial machinery & ICT (SIC3537-Industrial trucks and tractors) Transport equipment & aircraft (SIC3714-Motor vehicle parts and accessories) Miscellaneous consumer products (SIC3944-Games, toys, and children's vehicles) Transportation services (SIC7521-Automobile parking, SIC7549-Automotive services) Wholesale trade (SIC5013-Wholesale Trade-Motor vehicle supplies and new parts)
Transportation services	165	3	28%	22	Motor trade (SIC7521-Automobile parking, SIC7549-Automotive services) Marine technologies (SIC4581- Airports, flying fields, & services, SIC9621-Regulation, admin. of transportation) Communication services (SIC4899-Communication services) Trucking & warehousing (SIC4119-Local passenger transportation, SIC4212-Local trucking, without storage, SIC4213-Trucking, except local, SIC4214-Local trucking with storage, SIC4231-Trucking terminal facilities, SIC4731-Freight transportation arrangement)

					Marine technologies and Trucking & warehousing (SIC4173- Bus terminal and service facilities, SIC4729-Passenger transport arrangement, SIC4783- Packing and crating, SIC4785-Transportation Services-Inspection & fixed facilities, SIC4789-Transportation Services)
Trucking & warehousing	130	6	0%	13	Transportation services (SIC4119-Local passenger transportation, SIC4212-Local trucking, without storage, SIC4213-Trucking, except local, SIC4214-Local trucking with storage, SIC4231-Trucking terminal facilities, SIC4731-Freight transportation arrangement) **Marine technologies and Transportation services (SIC4173-Bus terminal and service facilities, SIC4729-Passenger transport arrangement, SIC4783-Packing and crating, SIC4785-Transportation Services-Inspection & fixed facilities, SIC4789-Transportation services)**
Transport equipment, aircraft & sp ace vehicles	101	5	8%	15	Industrial machinery & ICT (SIC3647-Vehicular lighting equipment, SIC 3663-Radio & TV communications equipment) Motor trade (SIC3714-Motor vehicle parts and accessories)
Marine technologies equipment & services	77	3	38%	12	Instrumentation (SIC3812-Search and navigation equipment) Utilities (SIC4499-Water transportation services) Transportation services (SIC4581-Airports, flying fields, & services) **Transportation services and Trucking & warehousing (SIC4173-Bus terminal and service facilities, SIC4729-Passenger transport arrangement, SIC4783-Packing and crating, SIC4785-Transportation Services-Inspection & fixed facilities, SIC4789-Transportation Services)** **Transportation services and Non-classified establishments (SIC9621-Regulation, admin. of transportation)**
Industrial machinery, ICT equipment & metal products	439	8	4%	73	Construction (SIC1731-Special Trade Contractors-Electrical work, SIC3499-Fabricated metal products) Instrumentation (SIC3568-Power transmission equipment, SIC3579-Office machines, SIC3825-Instruments to measure electricity) Transport equipment & aircraft (SIC3647- Vehicular lighting equipment, SIC 3663- Radio & TV communications equipment) Motor trade (SIC3537- Industrial trucks and tractors) Furniture, fixture & wood products (SIC3679-Electronic components, SIC3999- Manufacturing industries) Miscellaneous consumer products (SIC3357- Nonferrous wiredrawing & insulating, SIC3949- Miscellaneous Manufacturing Industries-Sporting & athletic goods) Utilities (SIC4911- Electric services) Software & computer services (SIC3571-Electronic computers) Wholesale trade of (SIC5023-Home furnishings, SIC5044-Office equipment, SIC5045-Computers, peripherals & software, SIC5046-Commercial equipment, SIC5063- Electrical apparatus & equipment, SIC5064-Electrical appliances, TV & radios, SIC5065-Electronic parts & equipment, SIC5072-Hardware, SIC5082- Construction & mining machinery, SIC5083-Farm & garden machinery, SIC5084-Industrial machinery and equipment, SIC5087-Service establishment equipment) Ultra-diversified (SIC3441-Fabricated structural metal, SIC3443-Fabricated plate work, SIC3448-Prefabricated metal buildings, SIC3449-Miscellaneous metal work,SIC3532- Mining machinery, SIC3669-Communications equipment) **Miscellaneous consumer products and Utilities (SIC3321-Iron & Steel Foundries-Gray & ductile iron foundries)**
Software & computer services	337	5	0%	25	Industrial machinery & ICT (SIC3571-Electronic computers) Miscellaneous services (SIC7629-Electrical repair shops)
Instrumentation	128	3	44%	10	Industrial machinery & ICT (SIC3568-Power transmission equipment, SIC3579-Office machines, SIC3825-Instruments to measure electricity) Marine technologies (SIC3812-Search and navigation equipment) Miscellaneous consumer products (SIC3842-Surgical appliances and supplies, SIC3851-Ophthalmic goods) Wholesale trade (SIC5094-Wholesale Trade-Jewellery & precious stones, SIC5139-Wholesale Trade-Footwear) Health services (SIC7352-Medical equipment rental)
R&D	250	4	0%	15	
Investment, business & management consulting services	688	9	0%	32	Utilities (SIC7349-Building maintenance services) Amusement & recreation services (SIC7336- Commercial art and graphic design) Wholesale trade (SIC5192-Wholesale Trade-Books, periodicals, & newspapers) Miscellaneous services (SIC7389-Security systems services)
Finance	66	1	81%	8	
Publishing	190	8	2%	17	Miscellaneous consumer products (SIC2752-Commercial printing, lithographic, SIC2759-Commercial printing, SIC2761-

					Manifold business forms, SIC2782-Blank-books and loose-leaf binders) **Amusement & recreation services, Health services, Miscellaneous services, Non-classified establishments, Ultra-diversified (SIC8999-Services)**
Wholesale trade	562	11	5%	52	Agriculture & farming (SIC5153-Wholesale Trade-Grain and field beans) Food processing, beverages & tobacco (SIC5143-Wholesale Trade-Dairy products, SIC5149-Wholesale Trade-Groceries & related products, SIC5154-Wholesale Trade-Livestock, SIC5182–Wholesale Trade-Wine & distilled beverages) Oil & gas (SIC5172-Wholesale Trade-Petroleum products) Chemical & allied products (SIC5169-Wholesale Trade-Chemicals & allied products) Industrial machinery & ICT (SIC5023-Home furnishings, SIC5044-Office equipment, SIC5045-Computers, peripherals & software, SIC5046-Commercial equipment, SIC5063- Electrical apparatus & equipment, SIC5064-Electrical appliances, TV & radios, SIC5065-Electronic parts & equipment, SIC5072-Hardware, SIC5082- Construction & mining machinery, SIC5083-Farm & garden machinery, SIC5084-Industrial machinery and equipment, SIC5087-Service establishment equipment) Instrumentation (SIC5094-Wholesale Trade-Jewellery & precious stones, SIC5139-Wholesale Trade-Footwear) Motor trade (SIC5013-Wholesale Trade-Motor vehicle supplies and new parts) Furniture, fixture and wood products (SIC5031-Wholesale Trade-Lumber, plywood, and millwork) Investment, business & management services (SIC5192-Wholesale Trade-Books, periodicals, & newspapers) Retail (SIC5131-Wholesale Trade-Piece goods & notions, SIC5136-Wholesale Trade - Men's and boys' clothing) **Agriculture & farming and Food processing, beverages & tobacco (SIC5159-Wholesale Trade-Farm-product raw materials)**
Retail	343	4	23%	37	Food processing, beverages & tobacco (SIC5421-Meat and fish markets) Wholesale trade (SIC5131-Wholesale Trade-Piece goods & notions, SIC5136-Wholesale Trade - Men's and boys' clothing) Hotels & restaurants (SIC5812-Eating places, 5813-Drinking places) Health services (SIC 5999- Miscellaneous retail stores) Miscellaneous services (SIC7623-Refrigeration service and repair)
Hotels & restaurants	71	2	68%	8	Retail (SIC5812-Eating places, 5813-Drinking places) Health services (SIC8059-Health Services-Nursing and personal care, SIC8069-Specialty hospitals exc. Psychiatric) Miscellaneous services (SIC8331- Social Services-Job training and related services, SIC8399-Social services) **Health services and Miscellaneous services (SIC8351-Social Services-Child day care services, SIC8361-Residential care)** **Miscellaneous services and Ultra-diversified (SIC8322-Individual and family services)**
Amusement & recreation services	200	4	29%	21	Miscellaneous consumer products (SIC3911-Jewelry, precious metal) Communication services (SIC7812-Motion picture & video production, SIC7819-Services allied to motion pictures, SIC7822-Motion picture and tape distribution, SIC7922-Theatrical producers and services) Investment, business & management services (SIC7336-Commercial art and graphic design) **Miscellaneous services and Ultra-diversified (SIC7999-Amusement and recreation)** **Publishing, Health services, Miscellaneous services and Ultra-diversified (SIC8999-Services)**
Non-classified establishments	183	2	72%	26	**Marine technologies and Transportation services (SIC9621-Regulation, admin. of transportation)** **Publishing, Amusement & recreation services, Health services, Miscellaneous services and Ultra-diversified (SIC8999-Services)**
Ultra diversified	568	22	0%	44	Industrial machinery & ICT (SIC3441-Fabricated structural metal, SIC3443-Fabricated plate work, SIC3448-Prefabricated metal buildings, SIC3449-Miscellaneous metal work,SIC3532- Mining machinery, SIC3669-Communications equipment) Miscellaneous services (SIC0751-Livestock services, exc. veterinary, SIC0752-Animal specialty services, SIC3931-Musical instruments, SIC7261-Funeral service and crematories, SIC7299-Miscellaneous personal services, SIC7363-Business Services-Help supply services, SIC7381-Detective & armoured car services, SIC7692-Welding repair, SIC7694-Armature rewinding shops, SIC7699-Repair services, SIC8299-Schools & educational services) **Amusement & recreation services and Miscellaneous services (SIC7999-Amusement and recreation)** **Hotels & restaurants and Miscellaneous services (SIC8322-Individual and family services)** **Publishing, Amusement & recreation services, Health services, Miscellaneous services and Non-classified establishments (SIC8999-Services)**
Total	951	6	18%	776	

Table 4. Distribution of employment and revenue per sub-region[******]

Region	Firms	%	Revenue	% R	ReplR	% rR	MeanR	Employment	% E	ReplE	% rE	MeanE
Brighton	19 290	10%	20 597 962	3%	6 207	32%	3 319	81 582	3%	1 189	6%	69
Canterbury - Medway- Tonbridge	34 271	18%	71 776 284	11%	10 220	30%	7 023	403 802	13%	2 588	8%	156
Guildford	24 769	13%	83 745 922	12%	8 691	35%	9 636	445 554	14%	1 493	6%	298
Milton Keynes	11 632	6%	56 403 707	8%	2 804	24%	20 115	224 909	7%	930	8%	242
Oxford	14 036	8%	36 558 627	5%	3 717	27%	9 836	193 677	6%	1 085	8%	179
Portsmouth	14 484	8%	32 325 764	5%	3 679	26%	8 787	124 577	4%	827	6%	151
Reading - Slough	38 495	20%	302 958 068	45%	11 956	31%	25 339	1 255 387	40%	2 918	8%	430
Redhill	16 614	9%	48 308 783	7%	5 395	33%	8 954	296 91	9%	1 344	8%	221
Southampton	15 379	8%	23 530 621	3%	4 066	27%	5 787	134 619	4%	952	6%	141
Total	188 970	100%	676 205 738	100%	56 735	30%	11 919	3 161 017	100%	13 326	7%	237

[******] The definitions of the indicators in this table are as follows:

Firms = Number of firms in cluster

% = % of firms in region from the total population

Revenue = Total revenue per cluster

% R = % of the total cluster revenue from the total population revenue

ReplR = Number of firms replied with revenue data

%rR = % of firms in each cluster replied with revenue data

MeanR = Mean revenue (average revenue per replied firm)

Employment = Total employment per cluster

% E = % of the total cluster employment from the total population employment

ReplE = Number of firms replied with employment data
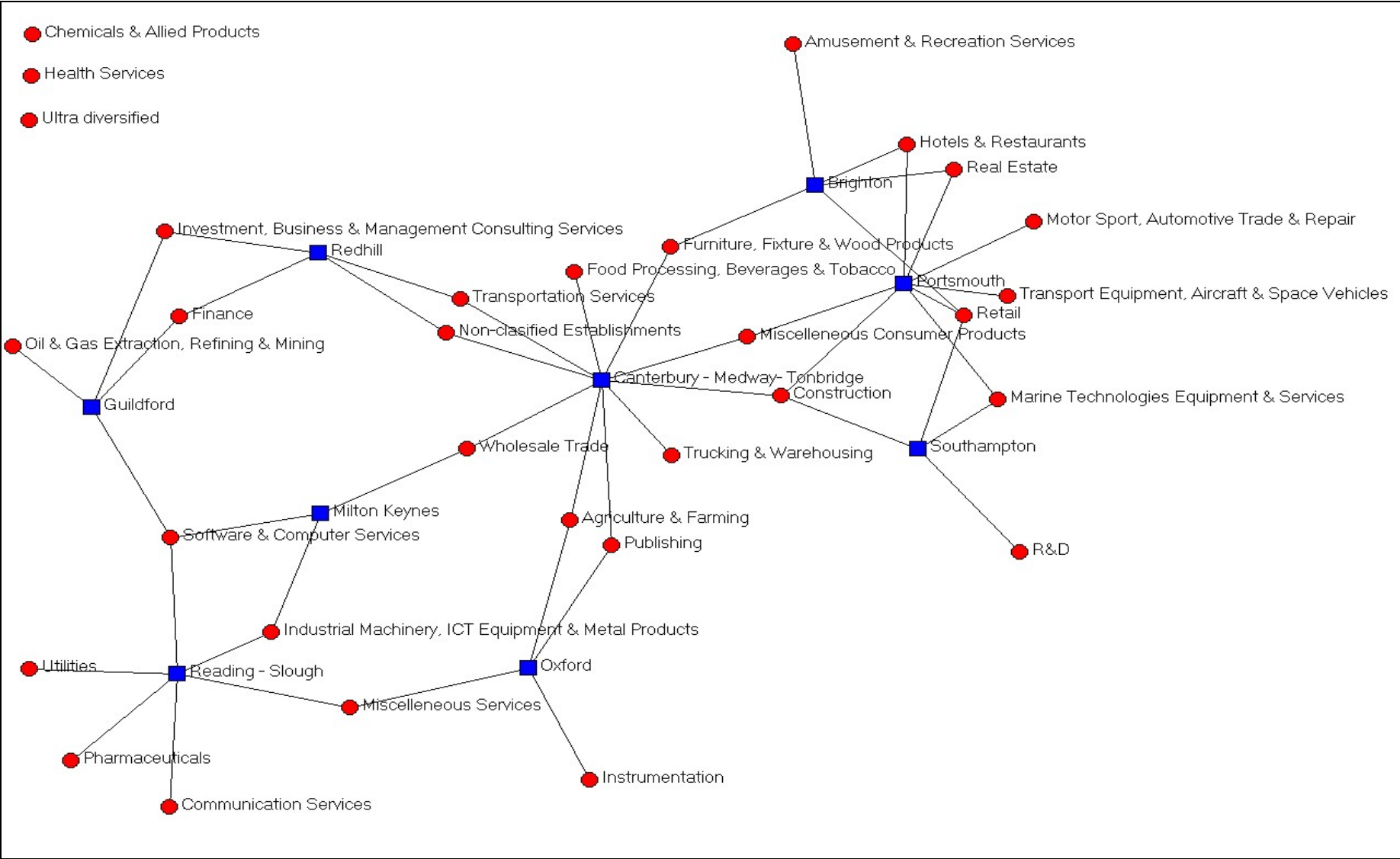
%rE = % of firms in each cluster replied with employment data
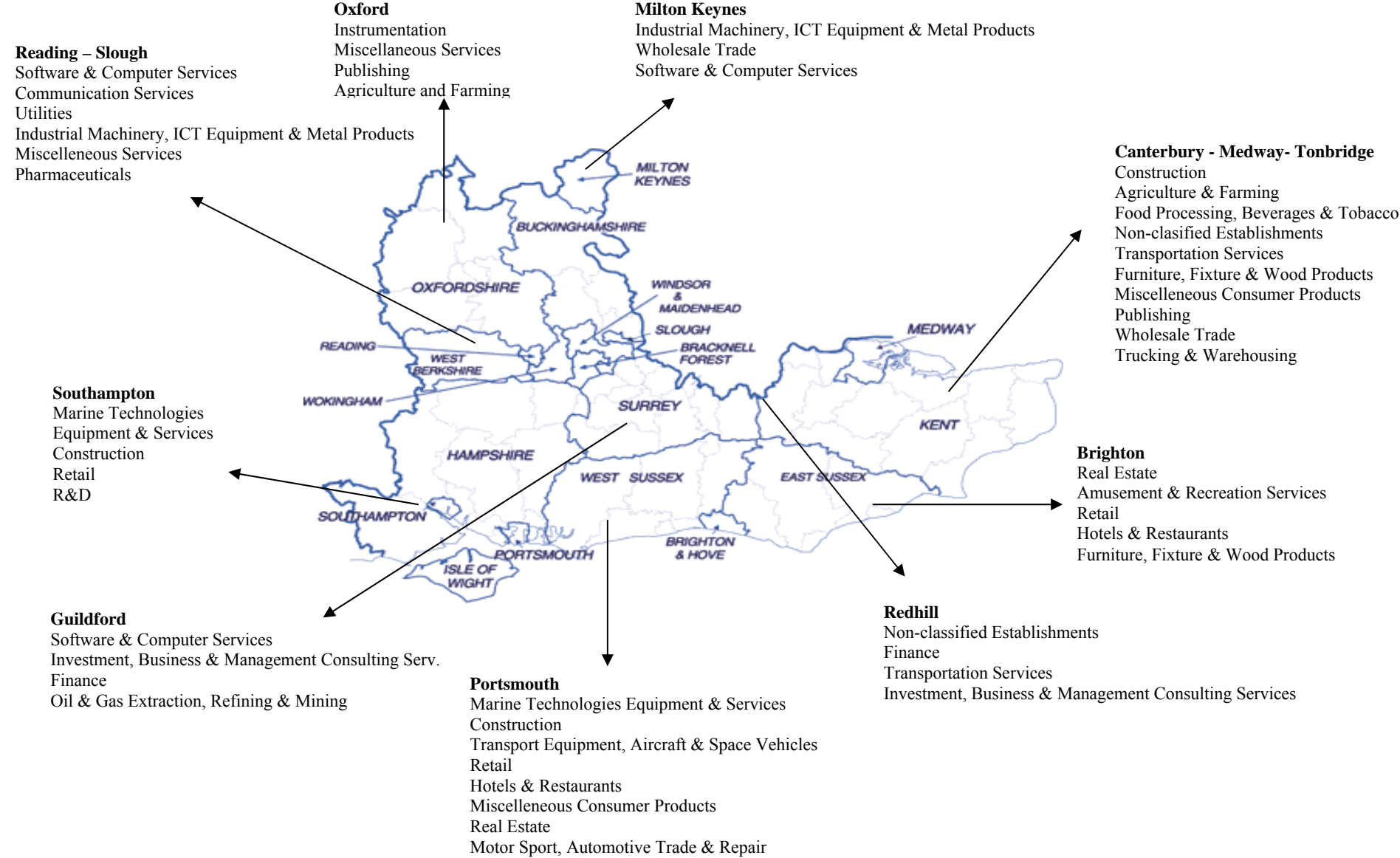
MeanE = Mean employment (average employment per replied firm)

Table 5. Cluster demography - distribution of clusters per sub-regions (number of firms)

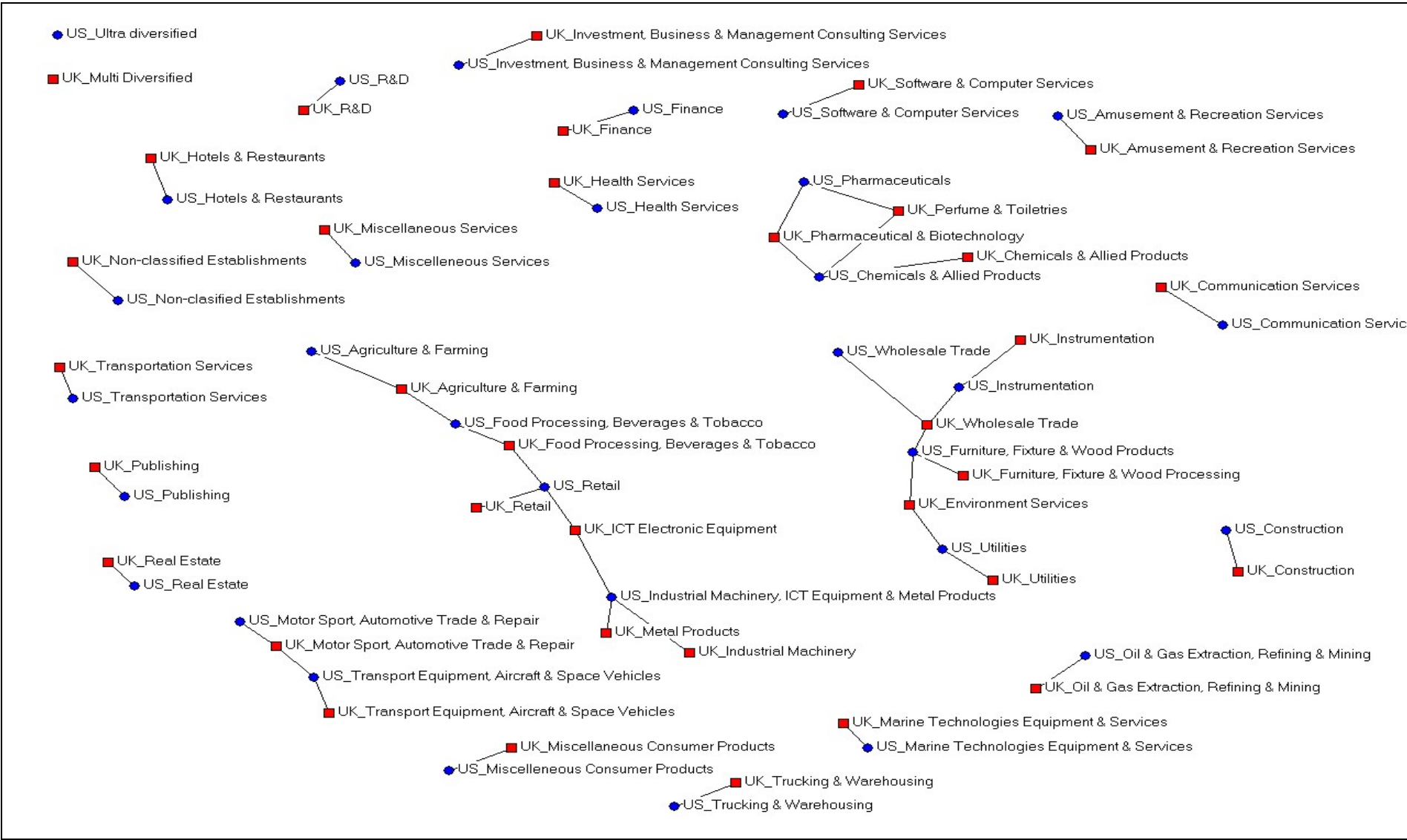| US Clusters	Brighton	Canterbury - Medway-Tonbridge	Guildford	Milton Keynes	Oxford	Portsmouth	Reading - Slough	Redhill	Southamp-ton	Total number of firms per cluster
Agriculture & Farming	142	499	142	113	224	145	212	120	172	**1,769**
Food Processing, Beverages & Tobacco	128	382	134	73	108	77	239	108	120	**1,369**
Construction	1560	3349	1606	814	951	1430	2375	1072	1519	**14,676**
Real Estate	2961	3552	2488	915	1180	1582	3202	1555	1462	**18,897**
Furniture, Fixture & Wood Products	167	320	135	71	118	94	181	81	87	**1,254**
Miscellaneous Consumer Products	218	455	208	135	137	202	334	183	170	**2,042**
Utilities	30	44	19	14	20	17	110	35	16	**305**
Communication Services	147	206	234	66	78	124	461	117	107	**1,540**
Miscellaneous Services	2843	5684	3844	1989	2545	2268	6666	2721	2290	**30,850**
Health Services	183	285	155	98	125	123	263	131	110	**1,473**
Pharmaceuticals	25	52	36	13	20	17	92	16	14	**285**
Chemicals & Allied Products	108	205	140	78	86	85	210	118	86	**1,116**
Oil & Gas Extraction, Refining & Mining	20	53	77	32	14	19	91	28	21	**355**
Motor Sport, Automotive Trade & Repair	301	670	413	242	279	317	619	267	329	**3,437**
Transportation Services	299	835	373	240	209	259	646	411	311	**3,583**
Trucking & Warehousing	33	105	48	26	25	27	78	46	37	**425**
Transport Equipment, Aircraft & Space Vehicles	41	46	48	22	34	52	59	19	35	**356**
Marine Technologies Equipment & Services	28	105	65	4	21	129	79	30	125	**586**
Industrial Machinery, ICT Equipment & Metal Prod.	440	875	630	448	404	415	1272	437	485	**5,406**
Software & Computer Services	2198	3042	3857	1671	1569	1581	6333	2172	1570	**23,993**
Instrumentation	97	148	111	80	106	96	222	92	75	**1,027**
R&D	360	599	586	226	334	284	778	348	433	**3,948**
Investment, Business & Manag.-Consulting Services	3393	6358	5562	2426	2890	2762	8096	3637	3282	**38,406**
Finance	176	319	359	80	101	115	385	245	132	**1,912**
Publishing	327	624	341	204	356	187	564	230	182	**3,015**
Wholesale Trade	567	1213	723	479	480	380	1299	525	447	**6,113**
Retail	801	1209	745	299	430	555	938	450	706	**6,133**
Hotels & Restaurants	430	583	388	158	247	294	464	253	283	**3,100**
Amusement & Recreation Services	735	948	640	262	400	405	825	434	339	**4,988**
Non-classified Establishments	362	1095	440	225	400	275	1031	579	293	**4,700**
Ultra diversified	21	67	51	23	33	20	86	40	33	**374**
Firms without SIC code	149	344	171	106	112	148	285	114	108	**1,537**
Total number of firms per sub-region	**19,290**	**34,271**	**24,769**	**11,632**	**14,036**	**14,484**	**38,495**	**16,614**	**15,379**	**188,970**

Map 35. Relations between clusters and sub-regions in the South East of England (13% of ties)

Map 36. Concentration of cluster activities per sub-regions in the South East of England

Oxford
Instrumentation
Miscellaneous Services
Publishing
Agriculture and Farming

Milton Keynes
Industrial Machinery, ICT Equipment & Metal Products
Wholesale Trade
Software & Computer Services

Reading – Slough
Software & Computer Services
Communication Services
Utilities
Industrial Machinery, ICT Equipment & Metal Products
Misceleneous Services
Pharmaceuticals

Canterbury - Medway- Tonbridge
Construction
Agriculture & Farming
Food Processing, Beverages & Tobacco
Non-clasified Establishments
Transportation Services
Furniture, Fixture & Wood Products
Misceleneous Consumer Products
Publishing
Wholesale Trade
Trucking & Warehousing

Southampton
Marine Technologies
Equipment & Services
Construction
Retail
R&D

Brighton
Real Estate
Amusement & Recreation Services
Retail
Hotels & Restaurants
Furniture, Fixture & Wood Products

Guildford
Software & Computer Services
Investment, Business & Management Consulting Serv.
Finance
Oil & Gas Extraction, Refining & Mining

Redhill
Non-classified Establishments
Finance
Transportation Services
Investment, Business & Management Consulting Services

Portsmouth
Marine Technologies Equipment & Services
Construction
Transport Equipment, Aircraft & Space Vehicles
Retail
Hotels & Restaurants
Misceleneous Consumer Products
Real Estate
Motor Sport, Automotive Trade & Repair

127

Map 37. Relationship between US - based and UK – based clusters (4% of ties)

- The use of a comprehensive database of all firms in the region enabled us to engage in a comparative analysis of clusters, not only in terms of their core industry structure, but also in terms of size and indicators of performance such as employment and revenue. The data in Table 4. shows that the sub-regions with the largest number of registered firms are: Reading-Slough, hosting 20% of the regional firms, followed by Canterbury-Medway-Tonbridge with 18%, and Guildford with 13%. The picture with the revenue per cluster and per sub-region is slightly different (see Table 4.). The firms in Reading-Slough contribute 45% of the regional revenue, while firms in Guildford contribute 12%, and firms in Canterbury-Medway-Tonbridge contribute only 11%. The sub-regions that contribute the lowest percentage of revenue are Brighton and Southampton with 3% of the regional revenue. The picture is similar regarding the contribution to the regional employment, where Reading-Slough contributes to 40% of the regional employment, followed by Guildford (14%) and Canterbury-Medway-Tonbridge (13%).

- The comprehensive database enabled us to calculate the relative weighting of individual clusters per sub-regions and to identify relative concentrations of cluster activities in different areas throughout South East of England. Table 5. and Maps 35 and 36 exhibit the results that we obtained from this analysis. The data in Table 5. exhibits the number of firms per sub-region and per cluster, which enables us to look at the relative concentration of firms in specific locations. For example, some clusters are highly concentrated in particular regions, such as 36% of 'utilities' (110 firms out of 305 for the cluster), 32% of the 'pharmaceuticals' (92 firms out of 285 for the cluster), and 30% of the 'communication services' (461 firms out of 1,540 for the cluster) are located in Reading-Slough. Another example is Canterbury-Medway-Tonbridge which hosts 28% of 'agriculture and farming' (499 firms out of 1,769 for the cluster) and 'food processing, beverages and tobacco' (382 firms out of 1,369 for the cluster). Other clusters, such as 'marine technologies' are shared between sub-regions – 22% (or 129 firms out of 586 for the cluster) are located in Portsmouth and 21.3% (125 firms) in Southampton, and the rest of the firms are distributed throughout the rest of the sub-regions.

- Map 35 represents an alternative analysis of the distribution of cluster activities per sub-regions, which is based on network analysis technique. The map represents relations between clusters and sub-regions at 13% strength of tie, where only the most significant

concentrations are highlighted. Three of the clusters remain un-associated with any particular sub-region, as their activities are distributed throughout the entire region. These are 'health services', 'chemicals and allied products', and 'ultra-diversified'. The other clusters are either associated with one, or with two regions. An exception is retail, which is associated with three sub-regions – Brighton, Portsmouth, and Southampton. These associations between clusters and sub-regions indicate relative concentration of cluster activities in the particular sub-region. The final details of this concentration are exhibited on Map 36, which shows the geographic location of all sub-regions, and the predominant cluster activity in each sub-region.

- Finally, we compare our clusters according to their composition of firms by US SIC industry code and UK SIC industry code. We applied the same approach using network analysis technique to investigate whether firms have declared the same activities by the US and the UK system (Map 37.). While dyads can be interpreted as strong correlation between firm membership in US clusters and firm membership in UK clusters, there are a few configurations, where firms have declared one set of activities in the US system, and another in the UK system. The examples of such associations between clusters are: firms that have reported their activities in the UK system as belonging to 'motor sport, automotive trade and repair' and the same activities using US industry codes for 'transport equipment, aircraft and space vehicles'. This is suggested also by Map 17, where motor parts are located as a separate segment from the main aircraft industry activities. Another example is the retail cluster, where firms report retail activities by the US system, but report different activities by the UK system, i.e. 'food processing, beverages and tobacco', 'ICT electronic equipment', or general 'retail'. Similarly, firms reporting in US SIC 'food processing' activities are split in their UK portfolio into those that put emphasis on 'agriculture and farming', and those that report 'food processing' activities. Firms in the UK 'perfume and toiletries' cluster are split in their reporting by US SIC into 'pharmaceuticals' and 'chemicals'. The US 'instrumentation' cluster is split between UK 'instrumentation' and UK 'wholesale trade'. Finally, the UK 'environmental services' is split between the US 'utilities' cluster and the US 'furniture, fixture and wood products' cluster. This analysis gives strong indication for the need to investigate more indepth the intra-cluster and inter-cluster activities, and to look at how these connected value chains affect inter-firm relationships.

- We used also a more standard method to test the overlap between the US and the UK clusters, and these results are shown on Table 6. The overall overlap between cluster membership of firm in the two systems is 91% for the entire population of firms and varies between clusters. The best overlap between UK and US clusters is for the 'real estate' and 'miscellaneous services' (98%), for 'software and computer services' and 'non-classified establishments' (96%), and for the 'finance' cluster (94%). The lowest overlap between UK and US clusters is exhibited for 'transport equipment, aircraft and space vehicles' (39%), 'instrumentation' (59%), and 'furniture, fixture and wood products' (62%). Overall, clusters with overlap below the average for the population 'share' firms with other clusters in the alternative system, and exhibit a link, which the network analysis on Map 37. has been able to reveal.

Table 6. Comparison of Industrial clusters in the South East of England

US SIC		Total firms by US SIC		% overlap between UK & US SIC
Agriculture & Farming		1767		90%
Food Processing, Beverages & Tobacco		1369		71%
Construction		14676		90%
Real Estate		18894		98%
Furniture, Fixture & Wood Products		1254		62%
Miscellaneous Consumer Products		2042		81%
Utilities (including Environment Services)		305		71%
Communication Services		1540		87%
Miscellaneous Services		30847		98%
Health Services		1473		85%
Pharmaceuticals (including Perfume & Toiletries)		285		93%
Chemicals & Allied Products		1116		82%
Oil & Gas Extraction, Refining & Mining		355		85%
Motor Sport, Automotive Trade & Repair		3437		90%
Transportation Services		3583		92%
Trucking & Warehousing		425		81%
Transport Equipment, Aircraft & Space Vehicles		356		39%
Marine Technologies Equipment & Services		586		91%
Industrial Machinery, ICT Equipment & Metal		5406		77%
Software & Computer Services		23989		96%
Instrumentation		1027		59%
R&D		3948		93%
Investment, Business & Management Consulting		38406		91%
Finance		1912		94%
Publishing		3013		92%

Wholesale Trade	**6113**	*78%*
Retail	**6133**	*77%*
Hotels & Restaurants	**3099**	*87%*
Amusement & Recreation Services	**4988**	*91%*
Non-classified Establishments	**4700**	*96%*
Ultra diversified	**374**	*1%*

- The results on Map 37 and Table 6 demonstrate, the unique power of network analysis technique that enable research to reveal not only existing links between objects, but also the strength of these links, and what stands behind an association. This report utilised multiple techniques, among which statistical cluster analysis and network analysis, and demonstrates the complementarities of findings. This approach was facilitated by the existence of a comprehensive database containing data for the full population of firms in the region.

- Leading assumptions in our approach are that clusters capture established inter-industry relationships, existing both within and between firms. We interpret the diversification of firms across industries as evidence of internalisation of parts of the value chain, and the integration of different industries within the portfolio of operations of firms. All cluster maps representing the core structures of clusters are defined on the basis of diversification data of firms registered in the South East of England.

- The network analysis of the clusters reveals their unique composition and structure and allows for future comparative analysis of dynamics and evolution. Overall our approach offers a new pathway for sectoral and regional economic research, where firms' activities and diversification are used to map economic entities such as regional and industrial clusters. The methodology for cluster mapping and cluster analysis registers innovation in cluster research that can establish scientific foundations for comparative cluster analysis and for future research of inter-firm relationships within and across cluster boundaries.

7. Glossary, Definitions and Abbreviations

ICT = information and communication technologies

R&D = research and development

UK SIC = UK Standard Industrial Classification System

US SIC = US Standard Industrial Classification System

NACE = Harmonised EEC Economic Activity Codes

NAICS = North-Atlantic Industrial Classification System

CSO = British Central Statistical Office

3-digit industry codes are not represented on individual cluster maps as they are reported by firms as a single industry code, and therefore can not be connected to any other industry. However, in some clusters they represent significant industry groups and encompass multiple industry operations.

Less connected codes are those industry codes that are below the threshold chosen for the cluster map (2%, 3% or 5% intensity of ties - depending on the size and density of the cluster), and do not appear on the cluster map that identifies the core industries. However, less connected codes have significant number of firms operating in the industry, and appear in Maps 32, 33 and 34.

Core industry codes per cluster are defined with the application of statistical clustering technique at the first step of the multi-stage cluster methodology for cluster mapping (see description in the methodology section).

Strength of ties is measured by the number of firms that declare simultaneously a pair of industry codes, and is calculated according to a formulae described in the methodology section (Formulae 1.). Strength of ties represents the largest positive values selected as the most significant ties on the basis of this formula.

The Percentage of ties represents a threshold that separates the most intensive ties from the rest. The number of firms per tie indicates the minimum number of firms that have reported the tie (or reported operations in each industry dyad).

The Size of the Dot represents how many firms have operations in a particular industry, and this number is described with the percentage in the code description table below each map.

The Percentage of Firms per Industry Code is given in the table below each structural map of individual clusters, and it shows the relative weighting of each industry in the cluster.

Nodes that are located in the periphery of a map usually are shared with other clusters, and hence are pulled from the centre of the cluster to the periphery.

A component is a distinctive group of interconnected industries that are clearly identifiable from the visual representation of the structure of each cluster.

A segment is a smaller section of a component, which has distinctive features, but is still an interconnected part of the component. Each segment is automatically coloured by the UCINET software as having different relations from the rest of the industries in the core structure.

Structural codes are those codes that constitute the core structure of individual clusters and are displayed on cluster Maps 1-31.

Connectivity codes are industry codes that act as bridges between value-added activities in individual clusters, and are displayed on Map 34.

8. Further Reading

Aldenderfer, M. and Blashfield, R. (1984) *Cluster Analysis*. Beverly Hills, CA: Sage.

Anderson, G. (1994) 'Industry Clustering for Economic Development', *Economic Development Review*, Spring 1994: 26-32.

Aydalot, P. (ed) (1986) *Milieux Innovateurs en Europe – Innovative Environments in Europe*. Paris : GREMI (Groupe de Recherche Europeen sur les Milieux Innovateurs).

Bartlett, C. and Ghoshal, S. (1986) Tap your Subsidiaries for Global Reach. *Harvard Business Review*. 64(6): 87-94

Birkinshaw, J. (2000) 'Upgrading of Industry Clusters and Foreign Investment', *International Studies of Management and Organisation*, 30(2): 93-113.

Blundel, R., Smith, D. (2001) 'Business Networks: SMEs and inter-firm collaboration', A Review of the Research Literature with Implications for Policy, *Small Business Services*, UK.

Boschma, R. (2005) 'Proximity and Innovation: A Critical Assessment', *Regional Studies*, 39(1): 61-74.

Ciccone, A. (2002) 'Agglomeration Effects in Europe', *European Economic Review*, 46: 213-227.

Cyert, R. March, J. (1963) *Behavioural Theory of the Firm*, Englewood Cliffs.

Doeringer, P. and Terkla, D. (1995) 'Business Strategy and Cross-Industry Clusters', *Economic Development Quarterly*, 9: 225-37.

DTI (2001) *Business Clusters in the UK – A First Assessment*. London: Department of Trade and Industry (DTI).

Everitt, B. (1993) *Cluster Analysis* (3 ed.). New York: Halsted.

Feser, E. (1998) 'Old and New Theories of Industry Clusters', in M. Steiner (ed) *Clusters and Regional Specialisation: on Geography, Technology and Networks*. London: Pion Ltd.

Feser, E. and Bergman, E. (2000) 'National Industry Cluster Templates: A Framework for Applied Regional Cluster Analysis', *Regional Studies*, 34(1): 1-19.

Goldstein, G. and Gronberg, T. (1984) 'Economies of Scope and Economies of Agglomeration', *Journal of Urban Economics*. 16: 91-104.

Gordon, I. and McCann, P. (2000) 'Industrial Clusters: Complexes, Agglomeration and/or Social Networks', *Urban Studies*, 37: 513-532.

Hill, Edward and Brennan, John (2000) 'A Methodology for Identifying the Drivers of Industrial Clusters: The Foundation of Regional Competitive Advantage', *Economic Development Quarterly*, 14(1): 65-96.

IMD (2003) *The World Competitiveness Yearbook 2003*, Institute of Management Development

Makhija, M. and Kim, K. (1997) 'Measuring Globalisation of Industries Using a National Industry Approach: Empirical Evidence Across Five Countries and Over Time', *Journal of International Business Studies*, 28(4): 679.

Marshall, A. (1890) 1919, 1927 *Principles of Economics*. London: Macmillan.

Marshall, Alfred (1927) *Industry and Trade*. London: Macmillan

Meyanathan, S. and Munter (1994) 'Industrial Structures and the Development of Small and Medium Enterprise Linkages. An Overview', in S. Meyanathan (Ed.) *Industrial Structures & the Development of Small & Medium Enterprise Linkages Examples from East Asia*. The World Bank: Washington DC.

Meyer, Arnoud (1994) 'Management of International R&D Operations', *Advances in Global High-Technology Management*, Vol. 4, Part B, pp. 3-18.

OECD (2001) *Innovative Clusters: Drivers of National Innovation Systems*. Paris: OECD.

Office for National Statistics (2004) *UK Business Activity, Size and Location – 2004*, London: HMSO.

Pandit, N. and Cook, G. (2003) 'The Benefits of Industrial Clustering: Insights from the British Financial Services Industry at Three Locations', *Journal of Financial Services Marketing*, 7(3).

Pennings, J., and Puranam, P. (2000) 'Market Convergence and Firm Strategies: Towards a Systematic Analysis', Presented at the 6th Annual *Organisation Science Winter Conference*, 9-13 February 2000, Keyctone, Colorado, US.

Piore, M. and Sabel, C. (1984) *The Second Industrial Divide: Possibilities for Prosperity*, New York: Basic Books

Porter, M. (1998) 'Clusters and the New Economics of Competition', *Harvard Business Review*. Nov-Dec.: 77-90.

Porter, M. (2000a) 'Location, Competition, and Economic Development: Local Clusters in a Global Economy', *Economic Development Quarterly*, 14: 15-34.

Porter, M. (2000b) 'Locations, Clusters and Company Strategy', in: G. Clark, M. Feldman and M. Gertler (eds.) *The Oxford Handbook of Economic Geography*, Oxford: Oxford University Press, 253-274.

Porter, M. (2001) *Clusters of Innovation Initiative*, San Diego, New York.

Roelandt, T. and den Hertog, P. (1999) 'Cluster Analysis and Cluster-based Policy Making in OECD Countries: an Introduction to the Theme', in: *Boosting Innovation: The Cluster Approach*, Paris: OECD: ch. 1: 9-23.

Scherer, F.M. (1971) *Industrial Market Structure and Economic Performance.* Chicago UP.

Taylor, P., Beaverstock, J., Cook, G. and Pandit, N. (2003) *Financial Services Clustering and Its Significance for London.* The Corporation of London.