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Oliver Emons

Innovation and Specialization Dynamics in the Automotive Sector: Comparative Analysis of Cooperation & Application Networks

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EUROPÄISCHES INSTITUT FÜR INTERNATIONALE WIRTSCHAFTSBEZIEHUNGEN (EIIW)/
EUROPEAN INSTITUTE FOR INTERNATIONAL ECONOMIC RELATIONS
Bergische Universität Wuppertal, Campus Freudenberg, Rainer-Gruenter-Straße 21, D-42119 Wuppertal, Germany
Tel.: (0)202 – 439 13 71
Fax: (0)202 – 439 13 77
E-mail: welfens@eiiw.uni-wuppertal.de
www.eiiw.eu

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Summary: This paper considers the innovation dynamics in the automotive industry of selected countries. Key elements concern the intensity of patenting networks. The role of innovation dynamics differs across countries which can be explained in terms of headquarter status, the vertical integration of the sector and the overall structural adjustment. A better regional R&D activity tends to stimulate regional economic development. In this context, clusters become more important, because these constructs are an instrument in promoting innovations, industrial development, industrial competitiveness and growth.

This is why we apply social network analysis methods to describe and measure the evolution of Cooperation and Application Networks in selected automotive-clusters in Germany and Austria. Scientist Mobility of inventors and the Cooperation of applicants lead to knowledge spillovers. These spillovers have a stimulating effect on innovative activity. To measure these effects we use patents of the European Patent Office (EPO), namely for 1992-2007. Social network analysis turns out to be quite useful in understanding the innovation dynamics in European Cluster Regions. Thus, we can draw some conclusions for the supply side dynamics in the EU single market and the automotive industry, respectively.

Zusammenfassung: Dieses Papier behandelt die Innovations- und Spezialisierungsdynamik in der Automobilwirtschaft. Dabei liegt ein Schwerpunkt auf der Intensität von Patentnetzwerken. Die Rolle von Innovationsdynamiken zwischen Ländern weist deutliche unterschieder auf, was bspw. durch eine unterschiedliche Funktion der Mutterkonzerne, der vertikalen Integration des Sektors, oder generell der durch die strukturelle Anpassung erklärt werden kann. Eine bessere regionale F&E Aktivität kann die ökonomische Entwicklung fördern. In diesem Zusammenhang stellen Cluster ein wichtiges Instrument dar, um Innovationen, Wettbewerb, industrielle Entwicklung und Wachstum zu fördern.

Die Soziale Netzwerkanalyse bietet im Zusammenhang mit regionalen Innovationssystemen die Möglichkeit Mobilitäts- und Kooperationsnetzwerke in ausgesuchten Automotiven Clusterregionen (in Deutschland und Österreich) zu beschreiben und zu messen. Diese Mobilität und Kooperation führt zu Wissensspillovern. Diese Spillover wiederum haben einen stimulierenden Effekt auf die Innovationsaktivität. Um diese Effekte sichtbar zu machen bedienen wir uns Patenten der Europäischen Patentamts (EPO). Dabei liegt unser Schwerpunt auf dem Zeitraum 1992-2007. Wie sich zeigt ist die Soziale Netzwerkanalyse bei dem Verständnis der Innovationsdynamik Europäischer Clusterregionen sehr hilfreich.

Emons Oliver, Research Assistant at European Institute for International Economic Relations (EIIW) at the University of Wuppertal, Rainer-Gruenter-Str. 21, D-42119 Wuppertal, Phone: +49-202-4391371, Fax: +49-202-4391377

emons@eiiw.uni-wuppertal.de , www.eiiw.eu

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1. Introduction

The strong global competition in the automotive industry – standing for medium and even high technology - reinforces the role of both product innovation and process innovation; therefore, expenditures on research and development (R&D) are important elements in the strategy of leading firms. At the same time, governments in countries and regions with automotive producers are interested in promoting regional innovation systems that reinforce the international competitiveness of automotive firms.

Improving regional innovation dynamics is a natural element of policies that focus on growth and innovativeness. Reinforcing regional R&D activities tends to stimulate regional economic development (HAFNER 2008, S. 40). In order to ensure future competitive advantages, it is important to keep up with the broad international technological development (BMBF 2007b).

In this context the German Federal Ministry of Education and Research (BMBF) points out that it is important to invest in R&D, education and skills in the future. Moreover, in the Report on Germany's Technology Performance 2007 it is well documented that Education and Research are therefore a top priority for the Federal Government. In this context clusters become increasingly important, because modern clusters are an instrument in promoting innovation, long-term industrial development, industrial competitiveness and growth (BAPTISTA/SWANN, 1998, 538). The existence of dynamic clusters with networked companies is crucial in various ways; certainly a cluster facilitates the exchange of knowledge in networks. Clustering offers advantages to all actors; from a policy perspective clusters are supposed to be promoted in structurally weak areas in order to become competitive and to prepare these regions for a more active role in globalization. International macroeconomic shocks – such as the banking crisis – and the surge of new Asian competitors have created considerable pressure in the EU automotive industry. The automotive industry is thus facing a broader restructuring phase and this will affect the relevant regions with considerable value-added of the automotive sector. The relevance of the automotive sector is emphasized in the High-tech Strategy of the German Government. Besides 16 other branches the automotive- and transport sector will be promoted (BMBF, 2007a, 18-19) in order to retain Germany's top position. Innovation processes are no longer dominated by OEM´s (Original Equipment Manufacturers) rather innovations are generated by automotive suppliers (Tier 1, Tier 2 and Tier 3). In the following sections of this paper it is shown that the exchange of knowledge - cooperation and mobility of scientists - can be understood as one of the most important determinants for the formation of innovations.

For innovation dynamics both cooperation between firms and mobility of employees/researchers are crucial. The following tables illustrate what is meant by cooperation and mobility (two different forms of knowledge spillovers). Mobility means that an inventor I1 has worked for two different applicants A1 and A2 on two different patents at a given time period. Cooperation of Applicants implies that at the time of t two applicants are listed on one patent. In that case, we suppose research cooperation. A definition of clusters and innovation networks is necessary to understand the connection between innovation and economic growth (section 2). The third section describes the social network analysis method and shows that the method is quite useful in understanding the innovation dynamics in European Cluster Regions in that way. Our Analysis looks at

Cooperation and Application Networks in three different automotive clusters in Germany and Austria.

Table 1: Mobility of Inventors

Mobility of Inventors		
	I1	**I2**
A1	t_0	t_1
A2	t_1	t_2

Table 2: Cooperation on Applicants in t

Cooperation of Applicants in t		
	E1	**E2**
A1	**Coop.**	-
A2	-	**Coop.**

2. Innovations Systems and Networks

One of the main questions in the last years is what the basics are for a successful innovation activity. One concept that tries to answer this question is the systems approach, which emphasizes the systematic character of the innovation activity and the role of innovation ability (CANTNER ET AL., 2009). It is undisputed that industrial innovations are generated systematically (Jungmittag 2000, 7-12). The generation of new knowledge is a process where many actors and institutions are involved. These actors are linked among each other and are interconnected. There also are several feedback mechanisms between these actors (WELFENS ET. AL., 2006, p.37). Consequently, these actors are integrated into a more or less wide-ranging system of other actors. The exchange of knowledge and know-how between actors implies that knowledge can diffuse easier. This tends to result in the creation of new skills. One result of the respective process is innovation resulting from the interplay of several specific ingredients such as innovative firms, universities and independent R&D labs.

2.1 Regional Innovation Systems

In addition to specific layers of innovation systems, the focus of this paper lies on the overall regional innovation system. In our analysis we explore one sector in two selected EU regions. A useful definition for regional innovation system is given by CANTNER ET AL. (2009). They define regional innovation systems as geographically confined **networks** of actors. These actors collaborate under certain basic institutional conditions in production, diffusion and utilization of new, economically usable knowledge. Following the idea of CANTNER ET AL., one may also look at the interaction of enterprises and research institutions. They also point out that the application of the systems approach to regional innovation networks relies on two basic findings:

1. the existence of regional effects of knowledge transfer (geographically closed spillovers)
2. the process of innovation must be seen as interactive, social network activities

The second finding assumes that the creation of new knowledge is a learning process that is based on the actors' experiences and learning from the experiences of other actors. This is defined as an interaction between different actors. There are various reasons for an interaction between actors. For example, the division of costs for R&D activities or the advantages in a joint exploration of new markets. Thus, the general conditions in the environment of the inventor play an important role in innovations. This should be considered when innovation processes are analyzed.

Cantner et al. call this the "collective invention" and emphasize that networks are a basic form of coordination for the exchange of knowledge. Thus, a network is characterized by an informal exchange of knowledge (know-how). The network stands for reciprocal and largely non-paid exchange of information. In this context, networks are relevant for example for the exchange of information on fairs, conferences or forums. One special form of information exchange is represented by research cooperation.

In line with our analysis we take a look at cooperation and application networks in the automotive industry. We use patents as an indicator to measure the relevant links and dynamics. On the one side, there are some disadvantages in the approach chosen. For example, not every element of new knowledge can be patented and therefore part of innovation dynamics is overlooked or not fully taken into account. On the other side, there are clear advantages: Patents and patent applications are indicators that are available over a long time period. A comparison of the advantages and disadvantages is shown in the following table.

Table 3: Advantages and Disadvantages of Patents ; Based partly on OECD (2008a)

Advantages	Disadvantages
- Existence of strong links between patents and inventions - Patents covering a wide range of technologies (partly no data) - Every patent document offers a lot of useful information about the generation process - The access to patent data over national and regional patent offices is easier by now (digital access) - Adequate geographical and chronological distance	- Not everything is patentable - The patent addiction is different (within the technology fields) - Some patents have a high industrial value, other patents have no value - There are differences in the patent laws – this is why the comparability between patent statistics is limited - Changes in the patent laws lead to difficult comparative analysis between countries - Patent data is complex - it is a result of a complex and economic process.

A patent offers a wide range of information. You can find the name and address of the applicant, who has the ownership. You can also find useful information like the name(s) and address(es) of the inventor(s) and about the technology classification (that must not be the same as the applicant.

2.2 Regional Innovation Systems

In conjunction with Clusters, networks play an important role, because knowledge and the exchange of knowledge are survival factors for cluster growth and for the cluster life cycle. One condition in cohesion with the systematic character is the existence of geographically closed spillovers. MARSHALL (1920) could show that there are three positive effects that are essential for the building of clusters. These are immobile local inputs, the local supply of qualified labor and the existence of knowledge spillovers. Our analysis is partly in line with the idea that the leapfrog of knowledge is one of the main conditions for the functioning of a cluster. [1]

One useful definition of clusters can be found by PORTER (1998). According to him clusters are: "[…] geographically close groups of interconnected companies and associated institutions in a particular field, linked by common technologies and skills. They normally exist within a geographic area where ease of communication, logistics and personal interaction is possible. Clusters are normally concentrated in regions and sometimes in a single town."

Table 4: Advantages and Disadvantages of Clusters

Concept	**Benefits**
Marshallian externalities	
Labor market pooling	Labor cost savings due to access to specialized skills, especially in an environment where quick turnaround is important
Greater variety of specialized intermediate goods and services	Access to a local supplier base that has more product variety and a high degree of specialization
(Tacit) knowledge spillovers	Access to tacit knowledge in geographic proximity by means of both formal processes as well as through such informal channels as knowledge leakages made possible by casual inter-firm interactions
Porter's market conditions	
Demanding customers	Motivational effects due to demands of highly competitive local customers that improve quality, cost, etc.
Rivalry	Motivational effects related to social/peer pressure

[1] see also AUDRETSCH, 1998; AUDRETSCH, 2000, JAFFE ET AL., 1993; FELDMAN, 2002

Complementarities	Better sales opportunities of firms due to search cost savings for the buyers of complementary products offered in proximity and privileged opportunities for co-operation (sales, marketing, etc.) between nearby suppliers of complementary products
Cost advantages	
Transportation	Transportation cost savings due to geographic proximity, especially in the case of just in time delivery contracts
Trust	Transaction cost savings due to an environment that encourages trust

Source: LUBLINSKI (2003), 453-467

Beside that definition there also other concepts describing similar processes and structures. All of these concepts exhibit one crucial similarity. Positive external effects are one main component of the analysis. These ideas are generated outside of the enterprise and cannot be characterized as the absorbent enterprise’s own investment (OECD, 2007, 26-28). Overall, the mobility of knowledge workers between enterprises must be emphasized.

In that case, an important part of knowledge has a personal bonded character. This knowledge is called „tacit knowledge“. Spillovers that appear with tacit knowledge are named knowledge spillovers (AUDRETSCH, 1998). Knowledge spillovers moved into the focus of the economic geography and the knowledge management particularly in the context of the new growth theory (KRUGMAN, 1991).

The authors JAFFE ET AL. (1993) found evidence that these spillovers have a regional effect. The development in dynamic high-tech clusters has shown that the number of moving personal between enterprises is higher than in non-clustered areas. The effect tends to stimulate ideas and knowledge and must be seen as an important reason for the success of the Silicon Valley (SAXENIAN, 1994).

The connection between actors is defined as social closeness (Cantner et al. 2009). Our study analyzes that construct. We assume that geographical closeness of the different actors is important but that it is no unique feature for the generation of clusters and innovations. BRESCHI/LISSONI (2003) have mentioned that a huge social closeness is one important condition for knowledge flow. Other authors defining different closeness forms (JÜRGENS ET AL. 2009) and emphasizing the construct of an “open innovation“. In the open innovation, not only the organization’s own innovation competence must be seen, the organization also has to integrate the information and competences of customers and suppliers. The interaction between different closeness forms is important.

A concrete description of closeness forms is analyzed in the paper of LAGENDIJK/ LORENTZEN (2007). The authors distinguish between geographical and organizational closeness. Thus, the interaction of both closeness forms is the basis for the building of local innovation systems and regional clusters will emerge in certain regions.

3. The Social Network Analysis

Social closeness is one important condition for theoretical constructs like clusters, networks and regional innovation networks. Our study analyzes the construction and interpretation of inventor networks. One method to measure the social closeness and to make it viewable is the Social Network Analysis. The method offers the possibility to identify the inventors who have worked for more than one applicant. The study of CANTNER/ GRAF (2004, p. 11) has found evidence that a strong exchange of inventors tends to result in a stronger connection between applicants. In order to measure the connection between the mobility of inventors and the cooperation of applicants, it is important to operationalize and measure the theoretical construct in order to describe it with an indicator variable. Firstly, the social network method will be described.

3.1 Basics of Social Netwok Analysis

The Social Network Analysis has emerged as an important technique in for example sociology, economics and social sciences (CANTNER/GRAF, 2004a, p. 2-3; SCHNEGG/LANG, 2002).

Mainly Social Network Analyses measure social structures (social networks). These structures can be seen as networks that basically consist of graphs. Graphs, in turn, consist of nodes and edges. These Nodes are equated with actors and the ties can be seen as the relations between these actors. Nodes for example represent humans, organizations, companies or even countries. Relations might be the exchange of information, goods or knowledge or the R&D cooperation between companies (KLOCKE, 2007, p. 138). In our analysis, it is not the attributes of the actors that are relevant but the relationship between these actors. Both the network as a whole an the individual actor must be analyzed. Mobility networks are defined as a network, where the nodes represent nodes and the connection between these nodes indicates that an inventor has worked for both applicants (on different patents). Cooperation networks are defined as research cooperation, namely in the form that both applicants are found on one patent.

3.1.1 Method

Our analysis offers a visual and a mathematical analysis of these relationships (HANNEMANN/RIDDLE, 2005). In the study we use patents as an indicator to measure the exchange of knowledge (knowledge spillover). If someone wants to create a network of applicants, the raw data have to be sorted and the database has to be refined. After some calculation steps, a symmetric matrix has to be generated, which shows the mobility of inventors. Considering that, we have to find a method to find the data that we need. For the construction of mobility networks we only use patents where at least one inventor lives in one of the examined regions of our analysis.

One step in our analysis includes the creation of a raw patent data table. We use the PATSTAT-Database of the European Patent Office that gives us access to 62 million patents (Oct. 2008) published at the office.

The procedure for the creation of mobility and for cooperation networks follows the same structure. As a first step, we create a table that includes the following information:

- Application date
- The inventors of the patent
- The applicant(s) of the patent
- The IPC-Classification

After some calculation steps, a symmetric matrix is generated. This table shows us the mobility of inventors.

A matrix *(M)* consists of *n* rows and *m* columns (n and m are equal to the number rows and columns).

The entries in the rows (*Mij*) of the matrix give us evidence of the kind of relation, therefore about the existence of the relation, the intensity between the row element *i* and the column element *j*. Secondly, we have to build a matrix where the applicants and the inventors are compared. If there is a connection between an applicant and an inventor, the corresponding cell of the matrix is unity. If there is no connection, the value is zero. Cantner and Graf denote this matrix as a "2-mode-Sociomatrix X". This matrix gives basic information about the dimension of the network. But for our analysis, it is necessary to implement another analysis step. The target is to exhibit a "*square matrix*". The matrix mirrors the connections between applicants. In order to build such a matrix, matrix X has to be multiplied by the transpose of matrix X. The result is a so-called adjacency matrix A. The matrix is symmetric. As a last step, the matrix has to be imported into a network visualization program (in our Analysis UCInet). The result is a visual presentation of the mobility network. Now it is possible to run a mathematical analysis.

3.1.2 Network Analytical Indexes

Our networks are general networks that can be analyzed in various ways. An example is found in SCHNEGG/LANG (2002). They talk of theoretical graphical concepts with which it is possible to make important and valid statements about a network. Both authors show this by means of the above already mentioned example of groups from the eastern central highlands of New Guinea described by different concepts. Furthermore, here, the potential of social network analysis becomes clear, which is not exclusively suitable for the visualization of relationships, but also for the supporting calculation of statistical parameters. In the literature on social network analysis, there are also other authors who prefer these concepts - or network analytical metrics - and underline the importance of the network analysis. For our purposes, the concepts of density and centrality are used in particular.

The ***density*** of a network indicates the proportion of effective relationships based on the possible relationships in a network. It is common to measure how closely a group is intertwined (WASSERMANN /FAUST, 1994; JANSEN, 2006, p. 94).

If g is the number of players, then the number of possible relationships is defined as:

(1) $g*(g-1)$

In this way, the entries are not observed in the diagonal of the matrix. The number of actual relationships is the number of ones in a matrix. This number of actual relationships is given by the abbreviation a. The density is defined as:

(2) $\frac{a}{g}*(g-1)$

The density is a simple concept. It must be respected, however, that the density depends on the size of a respective network. In this respect, it cannot be used for a comparison of our networks. It now says something about the individual network. If there were to be a comparison, ***the networks would have to be equal***.

The ***centrality*** offers us the opportunity to make further statements about the internal structure of a network. Firstly, we are interested in the so-called centrality degree. The centrality degree gives us the possibility to make statements about the position of each actor in a network. Thereby, the concept shows the number of relationships that every player in a network keeps with other actors in an examined network (KILDUFF/WENPIN 2003, p. 32). In contrast to the density, it does not describe the network as a whole, rather properties of the individual actors. It indicates the number of incoming and outgoing links to an actor. In the case of symmetric networks, incoming and outgoing links are identical (Schnegg and Lang 2002). In contrast to the density, the centrality degree of networks of different sizes could be used. For a comparison, we calculate the ***average centrality degree***. The average centrality degree provides information about the average connections each actor has to other actors in the network. The concept of components also gives us an opportunity to make important statements about the network. Components are interconnected segments of a network (WASSERMANN/FAUST, 1994, 109 ff.) As demonstrated in our networks, several subgroups are formed. There is no direct connection between these subgroups. Before we devote ourselves to evaluating the results in the following chapter, first we will show the automotive sector can be identified in the large number of patents.

4. Dataset

In every analysis it is important to get adequate data for the respective regions. In connection with the database there are several issues that need to be clarified in advance of our analysis:

1. What regions are to be considered or selected?
2. How is the sector identified in the patent database?
3. What period should be used to ensure a possible rational basis for comparison?

The following discussion will briefly focus on the issues raised.

4.1 Selected Countries

On the basis of various indicators, this chapter examines the choice of the different regions. Our paper offers an analysis of the SM for four European regions. The initial region consists of the cities of Solingen, Remscheid and Wuppertal. This region is known as the Bergish City Triangle. Furthermore, we dedicate ourselves to a comparison region in Austria. The innovation system of each country is discussed in detail. Secondly, we will give an overview of the NUTS3-regions within these countries. These regions have a reverence to the automotive sector. [2]

Table 5: Investigated Regions

Country	Investigated regions
Germany	'DEA18' Remscheid 'DEA19' Solingen 'DEA1A' Wuppertal
Netherlands	'NL413' Noordoost-Noord-Brabant 'NL414' Zuidoost-Noord-Brabant
Austria	'AT130' Vienna 'AT126' Vienna/ north 'AT127' Vienna/ south

4.1.1 Germany

A look at the following table illustrates the economic development of Germany in a direct comparison to the EU27-average values between 2004 and 2008.

Table 6: Gerenal Economic development of German

Indicator	National Performance		EU27 average	
	2004	2008	2004	2008
GDP per capita in PPS	116.3	115.6	100	100
Real GDP growth rate (annual growth rate)	1.2	1.3	2.5	0.9
Labor productivity [per person employed] (EU 27=100)	0.4	1.4	0.7	0.9
Employment growth (Annual % change)	0.4	1.4	0.7	0.9
Inflation rate (average annual)	1.8	2.8	2.0	3.7
Real unit labor costs (growth rate)	9.8	7.3	9.0	7.0

Source: INNO GERMANY (2009)

The real GDP in Germany grew by 1.3% in 2008, slightly higher than in the EU27. Another development is reflected in the unemployment rate. The rate decreased between

2 Nomenclature des Unités Territoriales Statistiques is a hierarchical classification, which divides the Member States for the purpose of statistical surveys conducted in three levels (NUTS 1, NUTS 2, NUTS-3)

2004-2008 but in 2008 the unemployment rate was above the EU average. In 2009, however, the GDP per capita in PPS was above the EU average, however, between 2004 and 2008, a slight loss of 0.7 PPS is shown (EUROSTAT, 2010).

Germany is a country that heavily depends on exports. This is reflected by the high export rate of 40% of GDP (2008). This dependence on global markets has led to the boom in these markets 2005-2008 and has also led to economic growth in Germany. Due to the worldwide recession, however, a drawback of this export-dependence can be seen. The industry has had to struggle with a severe drop in demand.

In May 2009, in a direct comparison with the previous month, a 17.9% decline in industrial production was observed (INNO GERMANY, 2009). Sectors with high research and development intensity were affected by this first; particularly the automotive and supply industry.

A look at the development of individual sectors of the German economy shows significant differences. Our analysis is mainly related to the automotive sector. The automobile industry has played an important role for Germany. Although automobiles are built by the major automobile manufacturers, there are a large number of international suppliers behind the OEMs providing complete system components as well as taking over a large part of the research and development process. The following table shows that German vehicle production has increased significantly since 1960. In 2007 Germany was the leader in the vehicle production (OICA 2008).

In the EU27, Germany boasts the most workers in the automotive industry. According to the ACEA 2007, 834,000 people were employed in this field. If the component industry is excluded, still 322,000 people were employed in that industry (VDI 2008). In addition to a continuous growth in employment, continued revenue growth can also be seen. The turnover in 1995 was approximately € 30 billion, twice as high in 2007 (VDA ANNUAL REPORT, 2009).

Germany's leading position in the car production is also proved by the fact that there is a high concentration of automobile manufacturers. A detailed list of all automotive and motors manufactures is listed in the appendix. The largest manufacturers are Volkswagen in Ingolstadt and Wolfsburg, BMW in Munich, Opel in Russelsheim and Bochum, Ford in Cologne and Daimler in Düsseldorf.

4.1.2 German´s Innovation System

The main comparative advantage of Germany, in contrast to other European countries, is that Germany has specialized in upscale consumer goods (machinery, automobiles, etc.). The strong demand from the catch-up countries, like China, has boosted the export-driven boom of recent years. The economic situation in Germany is characterized by a high proportion of research-and knowledge-intensive industries. The 2007 Technology Performance Report says that 39% of the total economic output is attributable to these industries. In particular, the research-intensive industry has a clear emphasis.

In 2005, Germany was the largest exporter of technology goods and achieved a surplus of €164 billion. This means that Germany ranked in second place ranked as net exporter of technology. This export success of the research-intensive industries in the recent years has been spurred in particular by the automotive, mechanical engineering and chemical industries. Between 2002-2004, two thirds of German industrial companies have been successful with product and process innovations. In this case, Germany took the top position in the European Union. Germany's economy thus has efficient production structures.

The strength of the German innovation system can be explained by the fact that there is an excellent research environment with a high number of renowned universities and research institutes. Furthermore, German researchers and companies are characterized by a high patenting propensity (INNO GERMANY, 2009a).

The expenditure on R & D amounted to € 53.5 billion in 2007. This means that total expenses, compared to 2006, increased by 2.8% (STATISTICS SCIENCE LTD, 2008). The financial crisis, and the global recession have led to the fact that the innovation system in Germany has changed considerably. There is serious business to generate innovation because access to capital is severely limited.

Table 7: R&D Indicators for Germany

	EPO patent applications * (intensity of patents)			**R & D expenditure as a share of GDP ****	
	Per 1 million inhabitants, by priority year			*In% of GDP*	
Time	UK	Hungary	**Germany**	**Germany**	EU27
2000	101,677	11,803	**268,869**	**2,45**	1,74
2006	49,707	8,754	**203,855**	**2,54**	1,76

Source: * EUROSTAT (2010); **taken from BMWF/BMVIT/BMWFJ (2009), as a share of gross domestic product – International Comparison

Looking at our analysis period, it is clear that there is a continuous increase in R & D expenditures in Germany. In the period of 2000-2006, R & D expenditures increased by 0.09%. On the other hand, there was a decrease in patent applications to the European Patent Office. Between 1995 and 2006, an increase in R & D expenditures from 2.2% to about 2.5% can be observed. It must, however, be noted that the target to spent 3% of the R & D expenditure to GDP ratio in recent years could not be realized (BMBF, 2007b).

The next years will show what impact the financial crisis will have on the patenting propensity of companies. In this context, many companies have postponed innovation projects because the access to new capital is difficult. The automotive industry is in a turbulent restructuring phase due to the ongoing economic crisis. Because of the high importance of employment in this industry and the high concentration of this industry on individual sites, these restructurings can give us evidence about the rise or decline of regions. The relevance of the automotive sector is also emphasized in the Hightech-Strategy of the German Government. Besides the other 16 branches, the automotive- and transport technology shall be promoted (BMBF, 2007a, S. 18-19) in order to retain the top position of Germany in the automotive industry in the future. In that case, the top international position of Germany in the vehicle, traffic and transportation technologies will be permanently guaranteed. Innovation processes are no longer dominated by the automobile manufacturers. Rather, more and more innovations are generated by the parts suppliers (Tier1, Tier2 and Tier3). The BMBF has indicated in a direct link with the development of clusters that the assets will produce innovations mainly due to the fact that knowledge can be exchanged quickly and efficiently. Furthermore, it must be possible to apply this knowledge (BMBF, 2007, p. 30-31). The BMBF also emphasizes that Clusters should be promoted. The automotive sector is often undervalued in its importance for the German economy. Statistics must always be regarded with a certain degree of distrust because not every company is included (KINKEL/ZANK, 2007, p. 10). It may happen that a company produces, for example, springs for pens and other suspension forks for vehicles. Despite this problem, the statistic gives us a first impression of the automotive sector. Accordingly, the total R&D expenses in the vehicle and especially in the manufacturing of motor vehicles have increased steadily (Wissenschaftsstatistik 2008).

4.1.3 Automotive Industry in North-Rhine Westphalia

The automotive industry has a high economic relevance for NRW. There are a lot of automobile headquarters –Ford in Cologne, Opel in Bochum and Daimler in Düsseldorf. Furthermore, large global automotive suppliers are located in North Rhine-Westphalia It extends the range of specialized electronics and component manufacturers such as Johnson Controls in Burscheid, Delphi in Wuppertal, TRW in Gelsenkirchen, Dusseldorf and Krefeld, specialists in body and chassis as Thyssen Krupp in Essen, Brose in Wuppertal or Edscha in Remscheid or specialists in the field of driving and motor, such as VDO, in Dortmund and Cologne or Pierburg Neuss. The fact that approximately 30% of all German suppliers come from NRW plays an important role for the selection of regions in this state, as well as the fact that this year about 7 million cars were produced in NRW. Furthermore, the automotive industry must be seen as the main source of exports for NRW. There is a high concentration of employment in Bochum (Opel), Cologne (Ford), East Westphalia, South Westphalia, the metropolis region of Düsseldorf and of course in the Bergish City Triangle (ZENIT 2007, p. 18). Universities with a technical background can be found in Dortmund and Münster, Universities in Aachen, Cologne, Duisburg-Essen, Gelsenkirchen, Bochum, Bielefeld und Wuppertal have a general background in the automotive industry (ZENIT, 2007).

An important aim of North Rhine Westphalia’s state government is to make NRW Germany's leading innovation state. The government has realized that clusters play a central role as drivers of innovation. The state government has identified a total of 16 regional clusters in which automotive cluster initiatives can also be found.

The NRW-Clustersekretariat has the main function to identify clusters in NRW and to assisst regional and industrial clusters (eg. the kompetenzhoch3 initiative in the Bergish City Triangle). In that case there are nine regional and industrial automotive clusters in NRW. One can also find cluster initiatives in Bochum and Aachen.

4.1.4 Automotive Industry in the Bergish City Triangle

The initial region of our analysis consists of the cities of Solingen, Remscheid and Wuppertal. This region is known as the Bergish City Triangle and has a particularly high density of automotive companies.

16,000 people are employed in the automotive competence field. These make up 7.5% of the total employees of the economic region. The “Bergische Entwicklungsagentur” (the development agency in Solingen/Remscheid and Wuppertal) exhibits that by the share of total employment, the importance of the competence field is 50% higher than for the entire state of North Rhine Westphalia (KOMPETENZHOCH3, 2009).

In the region, "Bergish City Triangle" there is a traditionally rooted and grown structure for automotive suppliers. These suppliers are OEMs (Original Equipment Manufacturers) and are positioned internationally with highly specialized products. Here you can find large anchor companies like Brose, Delphi and Johnson Controls (ZENIT, 2007).

4.2 Austria

4.2.1 The Austrian Economy

Since the 60s, the Austrian economy has experienced a fundamental transformation in a significant increase in the importance of the service sector (tertiary sector). This is primarily due to the gross value added of various economic sectors (identified two thirds of gross value added is generated by this sector). Second is the secondary sector with about 31% of the gross value added. The decline of the secondary sector, however, can be detected in almost all EU-27 countries

Taking a glance at current economic indicators for Austria itself, the GDP per capita, the real GDP growth and labor productivity has fallen per head (INNO AUSTRIA, 2009). In 2008 the recent financial crisis began. But in spite of the decline of the indicators, the growth of real GDP is well above the average of the EU-27. The inflation rate, unit labor costs and unemployment rate show an opposite effect, which were found to be well below this average in 2008.

Austria is a country that is very much affected by globalization. This can primarily be measured by the level of exports. This rate has risen from 34.9% in 1995 to 59.4% in 2008. The EU average was on 41.3% in 2008. But an increase in exports tends to result in an increased import quota. A look at foreign trade shows that Austrian export and import levels have doubled since 1995. The most important trading partner is Germany, because more than 40% of the imported goods come from, and about 30% of all exported goods go to Germany (STATISTIK AUSTRIA, 2009).

Other important trading partners are Italy, Switzerland, but also East European countries like the Czech Republic and Hungary. The export of goods is dominated by the Austrian automotive and engine manufacturers.

Table 8: General Economic development of Austria

Indicator	National Performance		EU27 average	
	2004	**2008**	**2004**	**2008**
GDP per capita in PPS	126.9	124.7	100*	100*
Real GDP growth rate (% change previous year)	2.5	1.8	2.5	0.9
Labor productivity per person employed (EU 27=100)	117.5	114.8	100*	100*
Employment growth (Annual % change)	0.4	1.6	0.7	0.9
Inflation rate (average annual)	2.0	3.2	2.0	3.7
Real unit labor costs (growth rate)	-1.8	0.6	-1.4	0.5
Unemployment rate as % of the labor force)	4.9	3.8	9.0	7.0

Source: Inno Austria (2009)

Austrian companies have recognized the opening of the East (Eastern enlargement of the EU) ("Eastern Europe" effect) as one of the first "early movers". Meanwhile, nearly 23% of merchandise exports went to Central and Eastern Europe. Furthermore, 20% of GDP have been invested in Central and Eastern European countries. Calculations of Industrialists (IV) show that the opening up of Eastern Europe and that Austria became a member of the European Union has resulted in a yearly economic growth of about 1% (IV, 2009).

Eight million people live in Austria. The country has 22 public and 11 private universities and 20 colleges and 16 teacher training colleges. A look at the R&D indicators in Austria show that, in contrast to Germany and the United Kingdom, a slight decrease in patent applications at the EPO was recorded. Furthermore, a significant increase in R & D expenditure up to 2.45% in 2006 was recorded. It is noteworthy that since 1997, Austria's R&D rate is above the average R&D spending within the EU and since 2004, even higher than the average rate of OECD countries. Since 2006, it is roughly on par with the rate of Germany (ÖTB, 2008). As in other OECD countries, the majority of the R&D expenditure in Austria is invested by companies.

Table 9: R&D Indicators for Austria

	EPO patent applications * (intensity of patents)			**R & D expenditure as a share of GDP ****	
	Per 1 million inhabitants, by priority year			*In% of GDP*	
Time	UK	Germany	**Austria**	**Austria**	EU27
2000	101,677	268,869	**147,361**	**1.92**	1.74
2006	49,707	203,855	**145,075**	**2.45**	1.76

Source: * EUROSTAT (2010); **taken from BMWF/BMVIT/BMWFJ (2009), as a share of gross domestic product – International Comparison

Meanwhile 2000 companies- mainly small-and medium-sized business enterprises- do research in Austria. International companies also provide a significant contribution to the research landscape in Austria.

Other important non-university institutions are the Austrian Institute of Technology (Research) (AIT) and the Austrian Academy of Sciences (basic research). The individual states' investment in research and development has also increased. A total of 49,377 people have worked in this area (2006), of which the majority has worked (more than 60%) in the company sector. A quarter of the researchers worked in the higher education sector. More than 70% of R & D expenditures are attributable to the corporate sector, which accounts for the largest part of the experimental development.

In a direct comparison of the federal regions, the largest share of expenditure on R&D can be found in the Vienna region (38.5%) and Styria (17.8%) (BMWF, 2009). In Austria, in contrast to other countries, a very high (above average) share of research funding is made by international companies with headquarters in Austria.

Through the development of Austria 2008 it seemed able to reach the Lisbon target of 3% of GDP.

4.2.2 Cluster Initiatives

In the 90s Austria has begun to systematically investigate and develop clusters. The first emergence regions of clusters were Styria (ACstyria Car Cluster) and Upper Styria. Now, cluster initiatives can be found in almost all provinces. An indicative list of cluster initiatives for the Vienna region can be found in the following figure (also includes cluster-like relationships).[3]

Table 10: Vienna Region – Cluster´ Initiatives

Vienna
Life Science Cluster Vienna Region
Automotive Cluster Vienna Region
Creative Industries Cluster
ICT Cluster

Source: CLEMENT /WELBICH-MACEK (2007), pp. 226/227

In recent years, Austria developed a cluster culture. Each state prefers its own approach. An Internationalized cluster, for example is the Life Science Cluster and the Automotive Cluster Vienna Region. In Austria, clusters currently serve mainly to increase R&D activity. The aim is to stimulate economic growth and the competitiveness of the country. Furthermore, Austria is involved in European cluster programs.

The PRO INNO Europe Cluster Alliances consists (among other) of one network that is named CEE Cluster Network, Cluster policy Networking and exchange via the themes of internationalization and incubation. This network was initiated under Austrian leadership (CLEMENT/WELBICH-MACEK, 2007, p. 34).

It is Remarkable for the cluster policy in Austria that clusters are indeed intertwined with many aspects of Austrian economic policy, but this integration is not very organized. One reason for this diffuse involvement may be seen in the strong alignment of the Austrian economic policy at the federal level (4 C foresees 2009, p.118). On the one hand regional cluster initiatives are encouraged to build on strengths, but on the other hand, federal limits should not be an obstacle to business cooperation. An example of a federal cross cluster initiative is the Automotive Cluster Vienna Region, which is part of the Lower Business Agency ecoplus and part of the Vienna Business Agency (4 C foresees, 2009, pp. 151 - 152).

4.2.3 Automotive Austria

Despite the fact that Austria does not have its own car brand, the automotive industry is economically relevant for Austria. In Austria there is, in addition to a strong network of automotive suppliers, strong expertise in research and development in the automotive sector.

Some regions show strong automotive clustering. The best-known clusters are in Styria, Upper Austria and Vienna. More than 175,000 people work in the automotive sector, with estimates distorted by an indirect employment (by the automotive industry) of 296,000 people in this sector. The supplier industry consists of 700 companies with an annual turnover of 20 billion Euros. In 2006 308,594 new cars were registered, while 242,211 cars were exported. This shows that the automotive industry can be considered to be one of the most important export industries in Austria. Almost 400 million Euros will have been invested annually in research and development.

Furthermore, the industry directly employs approximately 2,200 people in automotive research and development. Apart from the Austrian Research Centers, among others, the Joanneum Research and the Technical University of Vienna play a leading role in automotive research (ACEA, 2009).

4.2.4 Automotive Cluster Vienna Region

One of the main cluster initiatives includes the Automotive Cluster Vienna Region (4 C foresees 2009, p.118). After its founding in 2001, the number of members is 128 (including 63 manufacturing companies).

Table 9: Cluster Partners of the Automotive Cluster Vienna Region

Federal stat of the member	**Number**
Vienna	59
Lower Austria	43
Burgenland	3
Other partners	23

Source: ACVR (2009), data from 2009

With a turnover of € 4,932,841,289 (ACVR, 2010) and a total of 36,040 employees, it is one of the largest clusters in Austria (CLEMENT/WELBICH-MACEK, 2007, pp. 226/227). The focus is on automotive suppliers. These cluster offers (CLEMENT/WELBICH.-MACEK, 2007, p.154) advantages in the form of an information advantages, simplified contact to information, the opening of new markets and the initiation of collaborations.

Furthermore, the Automotive Cluster Vienna Region is involved in the Centrope Region (Central European region extended) (Automotive Cluster CENTROPE). This region is described as the Detroit of the East. This region covers Austria, Slovakia, Hungary, the Czech Republic, Romania and Poland and is becoming increasingly important for the automotive industry. This form of cooperation is supported by three major cluster initiatives. In addition to this, the ACVR (Automotive Cluster Vienna Region), the Automotive Cluster Slovakia and the PANAC (Pannon Automotive Cluster) are a part of the initial Automotive Cluster Centrope.

5. Results

After the above steps, it is now possible to generate and compare the networks of the automotive sector. Before we present the results, we will show how the networks have to be read and interpreted. In our analysis, we consider two forms of connections between applicants on a patent. On the one hand, we dedicate ourselves to the so-called mobility of inventors and on the other hand, we analyze the direct, joint cooperation of the applicant in the form of cooperation networks.

Cooperation networks are characterized by the fact that, because of a joint patent application by at least two different applicants, research collaboration has taken place. These networks are then read as follows:

- Applicants in the network are characterized by nodes.
- A connection between nodes ("deep") is the result of a cooperation of two applicants. Both applicants can be found on one patent. At least one inventor comes from the suspected region. In this way, we suspect research collaboration.
- The width of the connection ("tie strength") shows that the strength of the connection between two applicants. It shows the frequency of cooperation. With greater tie strength, a stronger cooperation relationship is suspected.
- It is quite possible that several applicants appear together. The result is a cooperation network.

Mobility networks are networks with the following unique characteristics:

- Applicants are represented by nodes.
- If there is a connection between nodes, inventor mobility is indicated.
- Inventor mobility means that an inventor can be found on two separate patents by two different applicants. This means that an inventor has worked for two applicants.

- In this case we assume that knowledge has spilled over.
- This form of knowledge transfer is called knowledge spillover.

Relationship Networks are networks that combine both of the above network types. Thus, changes in ***Cooperative Networks*** and ***Mobility Networks*** have a different influence on the respective relationship network.

The most important distinction between two types of networks can be explained by the fact that Mobility Networks reflect the unwanted transfer of knowledge (positive externalities) and Cooperation Networks reflect the direct wanted transmission of knowledge. Our study is based mainly on studies that make a geographical map on the basis of the residence of the inventor. The address of a patent applicant may be problematic, because many companies are parent companies with different settlements. The registration of a patent usually takes place at the address of the main headquarter. In this way, however, the place of knowledge creation is distorted (MAUSRETH/VERSPAGEN 2002).

5.1 Results for the Bergish City Triangle

We have decided to divide our study period into two periods (1992-1999 and 2000-2007). This results in two Relationship Networks for each region. Isolated Applicants (not linked to other actors) have been removed from these networks. The following table assists us in interpreting the respective networks. This table lists important information regarding the density of the network, the number of participating applicants (total + isolated Applicant), the average centrality-degree, the integration of research and development institutes and the centrality of the network. This information is divided into the cooperative network (Coop.) the Mobility Networks (Mobi.) and the respective Networks of Relationships for both time periods.

Table 10: Bergish City Triangle: Network Analytical Indexes

	Coop: 92 -99	**Coop: 00 - 07**	**Mobi. 92 - 99**	**Mobi. 00 – 07**	**RN 92 - 99**	**RN 00 - 07**
Applicants (total)	70	78 (+8)	70	78 (+8)	70	78 (+8)
Isolated applicants (total)	51	59 (+8)	50	62 (+12)	31	47 (+16)
Centrality of the network	2.74%	4.82%	3.42%	2.32%	12.53%	8.30%
Density	0.0095	0.0050	0.0120	0.0033	0.0232	0.0100
Participating applicants (total)	19	19 (=)	20	16 (-4)	39	31 (-8)
Average centrality-degree	0.657	0.385	0.829	0.256	1.600	0.769

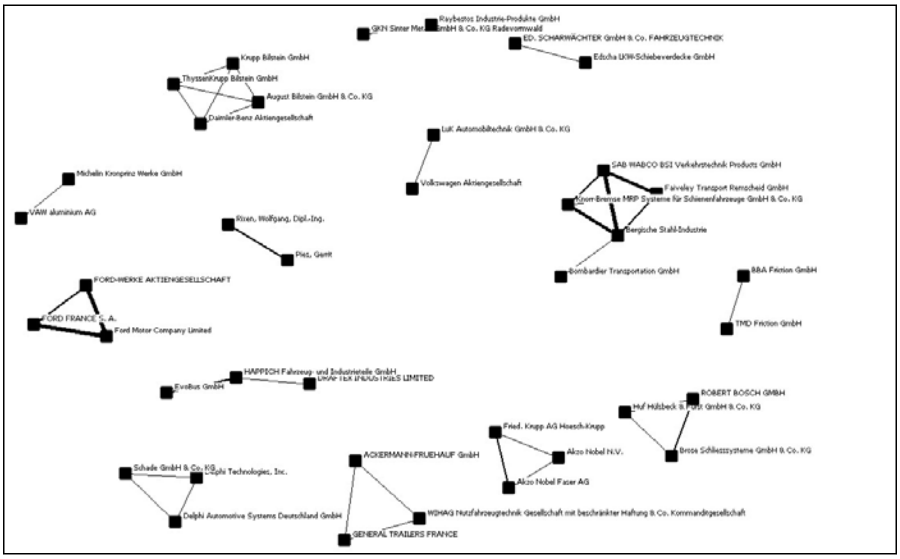
Integration of research and development institutes	No	No	No	No	No	No
“Star“ in the network	Ford Motor Company Limited; Ford Werke AG; Ford France S.A.	Ford Werke AG; Getrag Ford Transmissions GmbH; Endert, Guido	Bergische Stahl-Industrie; SAB WABCO BSI Verkehrstechnik Products GmbH; Knorr-Bremse MRP Systeme für Schienenfahrzeuge GmbH & Co. KG	Ford Global Technologies, LLC; Edscha AG; Getrag Ford Transmissions GmbH	Bergisch e Stahl-Industrie; SAB WABCO BSI Verkehrstechnik Products GmbH; Ford Motor Company Limited	Ford Global Technologies, LLC; Ford Werke AG; Getrag Ford Transmission GmbH

Source: own calculations

Before we devote ourselves to a comparative analysis for both periods, first similarities in the two networks will be analyzed.

The following two figures show the Relationship Networks of the Bergish City Triangle. A fist look at the networks shows that a mobility of inventors and a cooperation of applicants still exist. Both patterns of relationships have different intensity degrees, which is not necessarily self- evident, perhaps there are regions that have no mobility. It is also clear that in both networks only companies but no research institutes are listed. A study in the Healthcare Sector of the Bergish City Triangle (WELFENS ET AL., 2008) clearly showed that in case of mobility networks there are relations between research institutions and companies and that these connections are -against the background of a transfer of knowledge (knowledge source)- desirable.

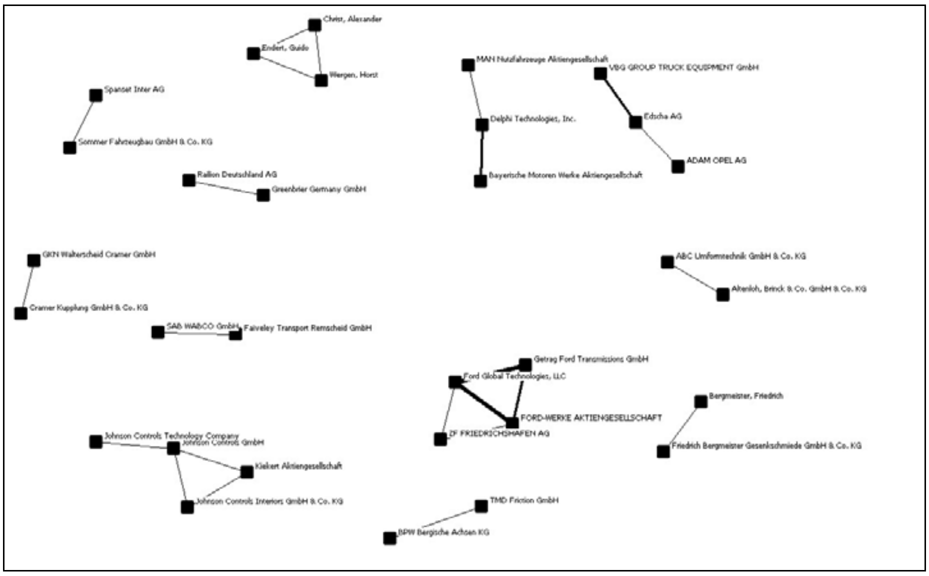
Figure 1: Bergish City Triangle: relationship Network 1992 – 1999



Source: own calculations

In this way we can identify the first problem within our network (regardless of the respective time period). The lack of involvement by research institutions in the networks of the Bergish Triangle cities must be regarded as a distinct disadvantage. From an economic point of view a university is both a service company in the field of higher education as well as an actor and research knowledge supplier. A part of knowledge is provided as a public good (e.g. via the Internet). In addition to the free codified knowledge, there are complex non-codified knowledge elements. Access to this knowledge, however, requires a proximity to the site of knowledge production. These conditions are given in the Bergish City Triangle, as a region with a university (and with neighboring sites), which provides science and economics courses. Leaders from politics, science and industry should contribute more strongly and must be involved more actively than before since the Bergische University of Wuppertal is a knowledge producer and a carrier of networks. There should be closer collaborations between companies in the region and the University of Wuppertal for example with the faculties of mechanical engineering and engineering. A further analysis of the networks shows that there is no shift towards a contiguous network. It is rather a collection of several components. The analysis also shows that, despite an increase in applicants, there is a trend towards increasing fragmentation. There are still relations between two or three applicants, but there are also larger identified components.

Figure 2: Bergish City Triangle: Relationship Network 2000 – 2007



Source: own calculations

There are a lot of global players represented within the networks.

Among other things, in both relational networks, the applicant Ford has several ties to partial or subsidiary corporations. Ford is one of the central players in both networks and has become more important (see Relationship Network from 2000 to 2007). Ford can be described as a "Star". A "Star" is a player that has the most connections with other applicants. A closer look at connections of players shows that Ford has the most links to subsidiary companies. Similar compounds can be identified in an analysis of the bivariate relations with respect to this special form of relationship. We define this special form of Scientist Mobility as an intra mobility of inventors.

Intra mobility can be dangerous, because if there is only one big central player in the network, a disappearance of this actor leads to -a strong expression of intra mobility within the network- possibly to the breakup of the network. Large anchor companies in the network (applicant) Brose, Delphi and Johnson Controls revert to research personnel from the region. This can be measured by the fact that all three companies are located in the mobility networks of the Bergish City Triangle.

If we take a look at the following table important statements can be made about the network. The density of the cooperation network decreases (from 0.0095 to 0.0050), as well as the density values for the mobility network (from 0.0120 to 0.0033). This loss of density leads to a decrease in the density value in the relationship network (0.0232 to 0.0100). The density is seen as a relative value but not independent from the size of the network.

To avoid distortions, the average centrality degrees for the individual networks are taken into account. This shows a decrease in values for both relationship networks (from 1.600 to 0.769). This declining trend can also be observed in the two other types of networks. The degree of centrality in the overall network (entire network centrality) also decreases (in all three network types). The relationship network centrality decreases from 3.18% to 2.34%. This decrease in network centrality is taken largely from the mobility network. Because of an increase in the actors involved in the networks, this decrease in values (absolute number of applicants) is rather surprising. The growth of isolated components, however, offers no adequate explanation here.

Summarizing these observations together now, it appears that the Relationship Network is moving in the direction of decreasing cohesion. This decrease in cohesion will be borne by the individual networks in very different ways. It is especially noteworthy that the mobility network is mainly responsible for the decline in the values of the Relationship Network. The cooperation network appears, however, not in spite of a constant number of connected players in a position to compensate this development. One can clearly speak of the loss of innovative capacity of actors in the Relationship Network. As a final point, it should also be mentioned that in the period of 1992-1999 a slightly higher willingness of companies' mobility can be realized, but over time however, the cooperation of applicants became more important.

5.2 Results for the Vienna Region

If one takes a look at the cluster initiatives of the Vienna Region, it is emphasized that there is significant expertise in the automotive sector. A first look at the automotive patent applications shows that the value is doubled within the two observation periods (368 applications to the EPO 1992-1999 to 664 applications in the second period). In this analysis, however, the Vienna region is clearly not responsible for this development (only a growth of four applications in the second period). This result is supported by an analysis of the network analytic metrics.

Table 11: Austria: Network Analytical Indexes

	Coop: 92 -99	Coop: 00 - 07	Mobi. 92 - 99	Mobi. 00 – 07	RN 92 - 99	RN 00 - 07
Applicants (total)	49	47 (-2)	49	47 (-2)	49	47 (-2)
Isolated applicants (total)	42	39 (-3)	45	45 (=)	40	37 (-3)
Centrality of the network	1.91%	3.02%	2.04%	2.17%	3.95%	2.97%
Density	0.0051	0.0074	0.0026	0.0009	0.0077	0.0083
Participating applicants (total)	7 (14.29%)	8 (+1) (17.02 %)	4 (8.1 %)	2 (-2) (4.3%)	9 (18.3%)	10 (+1) (21.3%)
Average degree-centrality	0.245	0.340	0.122	0.043	0.367	0.383
Integration of research	No	No	No	No	No	No

and development institutes						
“Star” in the network	DWA Deutsche Waggonbau GmbH; Volkswagen AGt; Siemens AG; Steyr Daimler-Puch AG	Volkswagen AG; Continental Automotive GmbH; Greenbrier Germany GmbH; Bombardier Transportation GmbH	Steyr Daimler-Puch AG ; Engineering Center Steyr GmbH & Co KG; Bombardier Transportation GmbH; DaimlerChrysler AG	MAN Nutzfahrzeuge Österreich AG; MAN Nutzfahrzeuge AG;	Steyr Daimler-Puch AG; DaimlerChrysler AG; DWA Deutsche Waggonbau GmbH; Volkswagen AG	Volkswagen AG; Continental Automotive GmbH; Greenbrier Germany GmbH; Bombardier Transportation GmbH

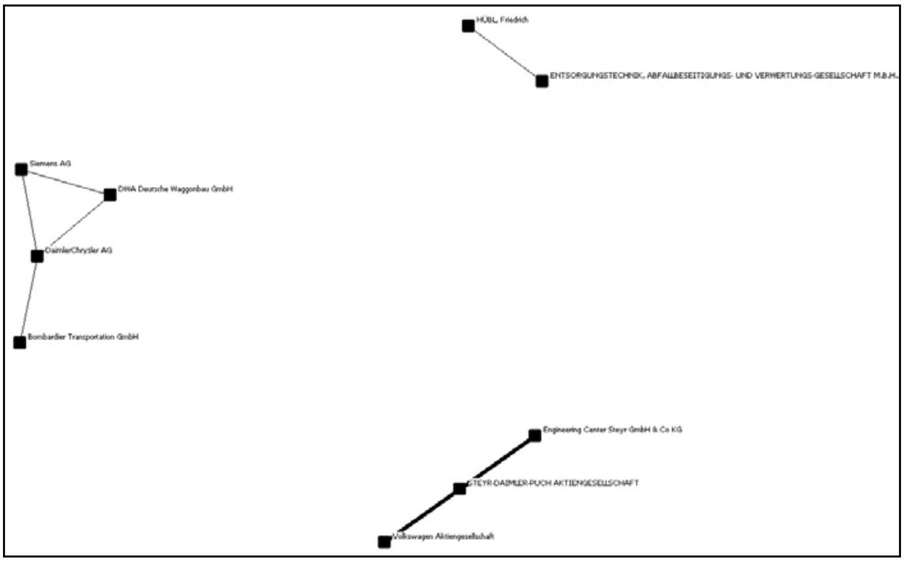
Source: own calculations

It is also clear that despite the slight growth of patent applications (+4) all types of networks have a slight loss of the absolute value of applicants (-2 each network). On the one hand, the number of isolated actors is either constant or declining; on the other hand there is an increase in the number of involved applicants in the Cooperation and Relationship Network. The growth in the Relationship Network has different reasons. The cooperation network has a stronger internal structure despite a declining number of applicants. However, there is a decrease of one half of the number of involved applicants in the mobility network.

In the first period there is little mobility and the existing structure is deteriorating significantly in the second period. The Automotive Cluster Vienna Region (ACVR) sees itself as a network that is, besides a promoter of innovation and an actor of pooling of competence, also an actor to promote and increase knowledge transfer. Comparing our results for the cooperation and mobility network, a knowledge increase in the Vienna region is limited. This approach is restricted because we measure spillovers on the basis of patents and unpatented knowledge is not taken into account (pure technical innovation) (FRIETSCH 2007, p.1). Furthermore, the mobility network carries the risk of intra mobility between related applicants in the second period. In that case it can be assumed that a "genuine" mobility network no longer exists. Moreover, the relationship between all of the applicants, the average related-degree centrality and the very small size of the network show that there is no internal structure. This is supported by the fact of low-density values for all networks. Research institutes are not actively involved in our network types. In the literature it is often assumed that agglomeration areas are economically very successful if they can be expected to be in classic technology locations with universities and research institutes. Belonging to these areas creates the opportunity to draw on a high and growing supply of people in technical jobs with university and college degrees (DÖRING 2004, p. 10). Central actors in the networks are DWA German Wagon GmbH, Volkswagen AG, Steyr Daimler-Puch AG and MAN Nutzfahrzeuge AG Austria. Volkswagen AG became a star in the Cooperation Network and the Relationship Network in the second period.

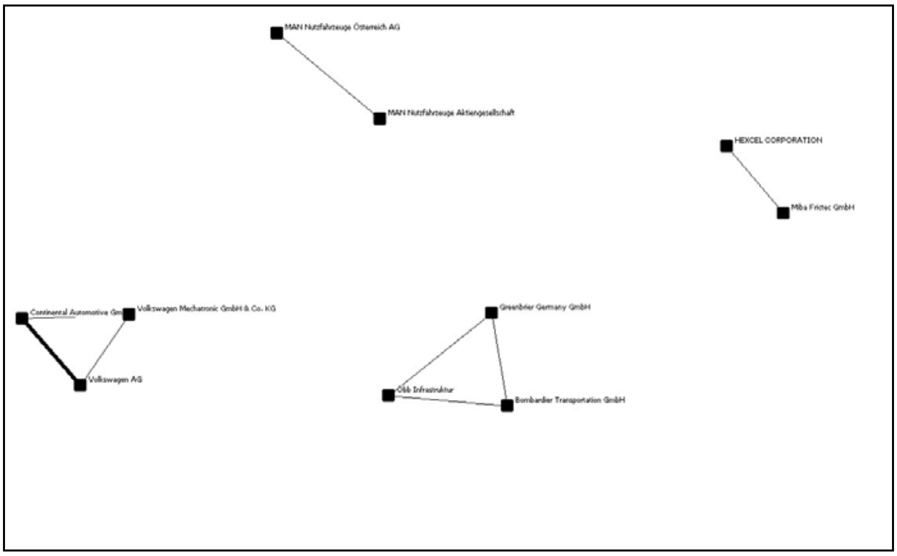
The results for the network analytic metrics suggest that a network of cooperation and mobility network exist in both periods. In the Cooperation Network there is a decrease in applicants. Despite the decrease, a stronger internal networking can be observed. In the first period the mobility network points out a very weak structure. In the second period, the mobility network exhibits another loss of the internal structure. A look at the Relationship Networks of the Vienna Region shows that neither of the actors can take a leading role. There is a central key player (FORD AG) in the network of the Bergish City Triangle. Furthermore, in the second period, the building components are more oblivious. In the first period there were three components. In the Relationship Network of the second period, a total of four components can be found.

Figure 3: Vienna Region: Relationship Network 2000 – 2007



Source: own figure

Figure 4: Vienna Ragion: Relationship Network 2000 – 2007



Source: own figure

The city of Vienna and Vienna region (NUTS3) accommodate a large number of automotive companies –e.g. Bombardier, MAN (Vienna, high-volume parts), Bosch, Magna Steyr and Eybl International (automotive textiles). Companies such as Volkswagen and Bombardier are represented in our networks in both periods. Here, the appearance and disappearance of applicants in the various relationship networks must be seen under the light of developments in the individual companies. The applicant Steyr-Daimler-Puch AG disappears in the relationship network for 2000-2007. This fact can be explained by a spin-off of business parts since 1987.

The business part of vehicle techniques was purchased by the Magna Automotive Group. In 1998, the majority of shares in the company Steyr-Daimler-Puch AG were adapted by the Magna International Inc. Magna Steyr AG & Co KG were founded in 2001. In June 2002 the company Steyr-Daimler-Puch AG & CO KG was renamed Automotive Magna Steyr AG & Co KG and STEYR Powertrain AG & Co KG was renamed MAGNA STEYR Powertrain AG & Co KG (MAGNA STEYR 2010). In the early 90s, Steyr Nutzfahrzeuge AG (trucks) was acquired by Man AG (MAN, 2010). The Power Transmission division was sold to ZF Friedrichshafen AG. Magna Steyr has not immersed as an actor in the Relationship Networks nor in Cooperation Networks and Mobility Networks. The headquarters of MAGNA STEYR AG & Co KG is located in Oberwaltersdorf. This region is part of the studied region NUTS3 AT127. The fact that the company does not appear in our networks as an active actor, it seems likely that the company does not work with inventors from the region.

The company Bombardier, in contrast, appears in two networks. Furthermore, it is striking that the company DWA German Wagon GmbH no longer appears as an actor in the Relationship Network from 2000 to 2007. The reason must be -similar to the development of MAGNA STEYR AG & Co KG- because of an acquisition of a competitor. In 1998, the DWA was taken over by the burly Canadian company Bombardier.

6. Conclusions

Network analysis is quite useful for understanding knowledge dynamics in the automotive industry. It has turned out that there are application- and cooperation networks in the automotive industry in both compared German and Austrian cluster regions that offer interesting inside views into the knowledge transfer (knowledge spillovers) of cluster actors; the role of regional innovation systems for example should be reinforced and adequate incentives for cluster formation could be useful.

It also has turned out that the relationship networks of the compared regions are unique. That results in different developments of these networks. So it is important not only to look at network analytical metrics but also on different economic developments (behavior of big OEMs that behave as anchor companies) in the regions that perhaps explain the different developments. In this context it is not easy to find universal instruments for cluster building. A loss of a big OEM for example will perhaps lead to a collapse of the whole network. So it is important to describe the role of an OEM or of a supplier. It is also important to identify reasons for the decrease the network structure or removal of an actor.

Reasons for the removal could be:

- Eliminated by the fact that the inventor of residence was taken in the selection of our patent data set for social networks (residence of inventors). This suggests that a company does not appear, because there is no recourse on research personnel from the region (see above).
- R & D of many German companies (suppliers) is done at German locations (KINKEL/ZANKER, 2007, p. 199); according to this actors do not appear because they do not exercise R & D activities at the foreign location.
- elimination of actors from a network through
    a. Outsourcing,
    b. Acquisition,
    c. Dissolve
- of companies (in all types of networks) (Case of Vienna region).
- Another reason for an international company may be the relocation of parts of the production (even relocation, and no active R & D activities in the region).
- Possible reason can be the elimination of a large supplier / OEM.
- Non-Application of a patent (the risk that a "double invention' is patented (HENTSCHEL/ KOLLER, 2007, p. 20-21).
- Profitability reasons (balancing of costs and benefits), especially in times of crisis. No application because there are economic reasons (economic and financial crisis).
- Knowledge inventories will be released by an actor; mobility perhaps is reduced and an actor may no longer appear as an active participant in a mobility network (for example Phillips in Eindhoven - Mobility Network for 2000 to 2007).

On the one hand the analysis offers important results for cluster management and cluster policy actors and a useful exploration of the EPO-Patent-Data Base respectively. On the other hand there are important new findings for cluster dynamics and for the “Social Network Analysis” but also the opportunity for further research (more countries, more sectors and more periods).

As regards policy conclusions one may suggests that future EU innovation policies as well as national innovation policies put more emphasis on efficient Schumpeterian networking; R&D support for cluster regions should be carefully evaluated and inter-regional benchmarking should be quite useful.

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