New Insights on the ICT Sector in Germany

Empirical Studies on ICT Firm Growth and Knowledge Spillover, ICT Cooperation Networks, and Early Stage Venture Capital Investments

by

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1. Introduction

1.1 About this Study

„Innovation is not the product of logical thought, although the result is tied to logical structure."

Albert Einstein (1879-1955)

The new growth theory emphasizes the role of know-how for economic growth.[1] If the capital stock is present, further economic growth will only be enabled by increase of the knowledge stock to use the present capital in a more productive manner (Romer 1986 and 1990, Lucas 1988, Grossman/Helpman 1991(a-c), Aghion/Howitt 1998). Knowledge is the basis for innovations that enable this more efficient use of productive capital while also meeting the increasing demand for differentiated products and services in countries with high per-capita income.

According to the new growth theory, spatial distribution of knowledge is free of friction, at least within the national economy. The endogenous growth theory highlights unintended knowledge spillovers, which means that business, in spite of patent protection, cannot fully contain the newly acquired knowledge. Since new knowledge cannot be protected comprehensively, other companies that do not conduct R&D will also benefit. These spillovers in addition to public knowledge created by universities and public research institutes, constant marginal yields on the macroeconomic level are generated. Lucas (1988) advances similar arguments, but emphasizes investments into human capital The latter increase productivity by gaining new knowledge, which is then transferred involuntarily to other economic agents, who are also able to work more productively. According to this view knowledge is a public good as it is created by one or more individuals and can be exploited by another without compensation. Nelson (1990) weakens this view and creates the term latent public good. The transfer of knowledge from an inventor to an imitator requires the capacity to absorb this knowledge. The imitator also has to invest in resources to apply the new knowledge (Cohen and Levinthal 1990). Therefore the incentive to invest in R&D may remain unaffected or be only slightly affected (Cantner et al. 2009). Knowledge is an entirely private good if it is incorporated in a person and associated with his or her talents. This kind of knowledge or a combination of specific resources which is not replicable is called tacit knowledge. Hence one can argue that knowledge as a good is in terms of exclusivity and rivalry neither a typically private nor public good and should be considered differentiated in this regard.

This ambivalent rivalry and exclusion degree is put in a context with the spatial agglomeration of companies as is often seen in regional economy. The basic idea of the new growth theory of friction-less distribution of knowledge is countered by the high regional company density concurring with increased

[1] Along with Döring/Schnellenbach (2006) in this thesis the meaning of knowledge encompass all cognitions and abilities that individuals use to solve problems, make decisions and understand incoming information.

"cycle speeds", in particular in case of tacit knowledge. Spatial proximity therefore leads to increasing knowledge spillover, e.g. by more intra-regional cooperation of companies among each other and with business and research facilities, or unplanned by increased workplace fluctuation of specialist human capital. In particular the first two of the three analyses in this thesis deal with the phenomenon of knowledge spillover or knowledge cooperation in relationship with corporate growth and innovation output. The third study deals with further phenomena that knowledge-intense companies are subject to and that is often an innovation inhibitor. Innovative companies are subject to increased financing restrictions. This corresponds to a lack of factual security, high risk due to new products and/or business models and information asymmetries between the innovator and capital provider. Funding therefore may be only possible by so-called venture capital (VC), since no funding alternative is available. VC, i.e. so-called risk capital, is provided in the form of equity capital by specialist capital providers in the industry. Availability through this specialized finance intermediary varies greatly within the OECD or EU countries.

The present work contains three essays that deal with the subject of the phenomena named, which are significant for growth of the economy. First, dynamically growing companies are empirically compared to less quickly growing companies in the context of spatial agglomeration or knowledge spillovers. The following chapter illustrates cooperation networks of innovators in German cluster regions – regions that show a spatial agglomeration of companies of one corporate sector. The third analysis shows whether the respective national finance system of selected OECD countries affects venture capital investments in the early stages of a company. The three essays therefore can be assigned to regional economy, innovation economy and finance economy, with some subject overlaps, so that a clear differentiation is not very sensible. The chapters form self-contained analyses.

Since certain features are typical for different business sectors, so that empiric results cannot always be easily transferred to other sectors, this thesis mainly focuses on the sector of information and communications technology (ICT). The present dissertation explicitly deals with the ICT sector in Germany in chapters two and three. The fourth chapter contains a panel analysis comprising several countries and covers young, innovative companies in a more general manner and merely indirectly in an explanation of various early stage venture capital investment levels in these countries.

In addition to the hopefully interesting and scientifically well-founded contributions, this dissertation is special because of its use of diverse methods and observation levels to adequately examine the matter at hand. Starting with a micro-economic cross-sectional analysis mainly based on corporate data collected by the author in an electronic questionnaire, it presents a special network analysis based on patent data in the following chapter. This analysis can be assigned to the meso level because of its regular focus on two NUTS-2 regions. The third analysis is a panel analysis including 16 different countries, giving it a macro-economic character.

Before briefly presenting the individual chapters to in particular point out the subject relationship, I will briefly deal with the author's motivation for choosing the ICT sector.

The motivation to deal with the ICT sector could be seen as quite obvious. The arguably most important technological innovations of the past decade were initiated by ICT. Thus the ICT sector, compared to the overall value creation development, grew very quickly. At the same time, the implementation of ICT technology and infrastructures increased productivity in nearly all other sectors of the economy. Hence, a vital ICT sector is of great importance for Germany and is likely to enhance its international competitive position even further. The information and communication industry is already one of the largest economic sectors of Germany. At the same time, it is an important motor for innovation, growth and employment in other areas of our economy. It is a sector with currently about 843,000 employees and a turnover of nearly EUR 150 billion in 2010 (BITKOM), notwithstanding the fact that the prices of many ICT products have shown a continuous decline in effective prices for a long time. The German ICT sector accounts for approximately 6% in 2010 of the worldwide market in information and communication technology. This makes Germany the fourth largest national market in the world, following the USA, Japan and China, and the most important market for ICT in Europe. The European Commission estimates that ICT contributed with approximately 40% to the increase of productivity in the European Union in recent years and, thus, was the single most important source of productivity growth.

The revitalizing effect of ICT on other sectors of the economy and the growth of the ICT industry are mutually interdependent. The domestic ICT services industry plays an important role for small and medium enterprises (SMEs). The presence of nearby ICT service providers enhances the competitiveness of local SMEs and makes it possible to provide solutions tailored to the needs of each business. A highly-developed domestic ICT services sector essentially reduces dependency on suppliers abroad and any deadweight effects. Lively competition with regard to digital solutions for local SMEs will either tend to increase innovative capacities of ICT businesses or result in declining prices for such services. This, in turn, may lead to increased export activities and reinforce E-Government activities in the public sector with an ensuing enhanced efficiency of public services. There are numerous other positive (welfare) effects of ICT, such as the development of "green IT", an extension of available educational and training facilities and positive impacts on the health sector.

Supranational, national and regional levels of politics alike have recognized the relevance of ICT for a dynamically growing economy. Promotion of ICT is specifically considered in the seventh research framework program of the European Commission. For 2011-12, eight “challenges” are phrased to be promoted. According to further explanation, it is of special strategic interest for the European society that research in the area of future technologies and support of horizontally aligned cooperation be enforced.[2] The promotion volume of the seventh research framework program amounts to 9.1 billion Euro across a period from 2007 to 2013, forming the largest promotional item in the seventh framework program. On the level of national or German politics, ICT promotion is an important component for promotion of the economic site as well. The Federal Ministry for Education and Research (Bundesministerium für Bildung und Forschung; BMBF) contributed to ICT project promotion and ICT institutional promotion with

[2] http://cordis.europa.eu/fp7/ict/ (accessed on March 2012)

approx. 3.2 billion in the period from 2007-2011.[3] As part of the high-tech strategy for Germany, promotion integrated SMEs more strongly than before under the umbrella of "IKT 2020". Increased value was placed on ICT comprehensive cooperation. Even beyond 2011, ICT promotion is still essential in high-tech strategy. The high-tech strategy or so-called "area of demand" of ICT was revised under supervision of the Federal Ministry for Economy and Technology (Bundesministerium für Wirtschaft und Technologie; BMWi), as well as in cooperation with the BMBF and the Federal Ministry of the Interior (Bundesministerium des Inneren; BMI). The ICT strategy of the BMWI, called "Deutschland Digital 2015" (BMWi 2012a), contains all promotional activities of the ministry and the annual IT-summit of the Federal government for recording important IT trends or developing concepts for how to strengthen Germany as an IT site. One subject focus is that of internet-based services for the economy.[4] This includes terms like "Internet of Things" or service-oriented architectures, web services and cloud computing. The Federal government states in its current high-tech strategy that we are at the threshold of the fourth industrial revolution, referring to the merger of the real and internet-driven virtual worlds. This shows clearly the overall economic importance of ICT in the awareness of many political decision makers. Even with the current great effects of the internet, the importance of future developments cannot be estimated too highly. Economic growth will increase in quality as well. It may increase a society's quality of life, as already mentioned, and help in solving important problems. "*Digital refinement of production plants and industrial products into everyday products with integrated memory and communications features, radio sensors, embedded actuators and smart software systems builds a bridge between the real and virtual worlds* " (BMWi 2012b p.52/own translation). Countries that develop innovative products in this area are able to achieve high value generation and ensure or develop wealth in an environment worth living in. Suitable political instruments for this must be used and mis-developments of the promotional instruments utilized must be uncovered at an early stage.

The objective of this dissertation is making a new contribution to this. First, ICT companies that are more successful than others will be identified and characterized. Analyses are performed to find out whether companies profit from proximity to others of the same industry. Entirely new data had to be generated to perform such analysis. Furthermore, ICT patent data of companies in so-called cluster regions and the dynamics of research cooperation across time are analyzed and spatial development is visualized. New insights in possible economic effects of clusters of high spatial corporate density are presented to better understand them and to enable well-founded assessment on cluster promotion as an important economic promotional instrument (see, e.g., the cluster of excellence competition as a high-tech strategy or German competence network flagship). The fact that nationally grown economic structures generally must be observed is emphasized, among others, by the third empirical analysis of this paper. Venture capital is a

[3] http://www.bmbf.de/pub/ikt2020.pdf (download on March 2012)

[4] Of course, the ICT strategy of the Federal government comprises many other subjects, such as development of broad-band high-performance infrastructure, IT safety, IT competence or education, E-Government and many others (see http://www.bmwi.de/Dateien/BBA/PDF/ikt-strategie-der-bundesregierung,property=pdf,bereich=bmwi,sprache=de,rwb=true.pdf (download on March 2012). In this area alone, 127 promotional measures are described to implement the ICT strategy of the Federal government by 2015.

much more important funding source for innovative companies in the US and therefore also for ICT companies than in Germany. Among others, this is due to the much higher importance of the historically developed banking system in Germany, which is subject to different regulatory effects, as is made clear by a panel analysis that was performed under inclusion of other EU countries. In the following, these three analyses are dealt with in more detail.

1.2 Overview

1.2.1 Regional and Company-specific Factors for High Growth Dynamics of ICT Companies in Germany

In view of the significance of ICT businesses, it is rather astonishing that there are only comparatively few studies on the specific regional and company-specific impact factors for high corporate growth dynamics. This may be due - as so often - to the dearth of data available to carry out such an analysis. At the same time, identification of factors that support the positive growth effects of ICT businesses would be of great importance in the context of a targeted economic policy (BMWi 2009). Even in a single European economic area, businesses still find themselves, due to differing national institutions and economic structures, in differing country-specific environments, which contribute to the success or failure of their economic activities. This aspect has an even greater relevance for sector-specific analyses.

To be able to make meaningful recommendations for future actions, the analysis in the following chapter interviewed ICT companies in Germany. The information gained was evaluated by means of a probit model and provides insight into regional and company-specific impact factors that are factually relevant to enhance the growth opportunities in each specific case. More than 200 companies returned the completed electronic questionnaire. The information submitted provides answers to the question on how in particular knowledge spillover but also capital structure, company age and size and export activities have an impact on growth dynamics. "Knowledge spillover," the intentional or unintentional "spillover" of know-how between economic actors is considered to be an important phenomenon for the dispersion of knowledge, in particular in innovation-driven sectors. According to (recent) economic geography and/or location theories, spatial mobility theories and regional growth and development theories, clusters are considered to be beneficial for stimulating an exchange of knowledge. Accordingly, a cluster development strategy - the formation of networks of closely cooperating companies that are in close regional proximity to each other and whose activities supplement each other along one or several value added chains - is considered to be an important economic policy tool that is currently widely used by economic policy-makers.

The aim of the networking is to enable and stimulate knowledge spillover. The economic policy instrument of actively supporting networking activities between businesses on a meso-level became "fashionable" in the nineties and has been used ever since to an increasing extent by political decision-

makers. This leads to the question if this active support, as currently practiced, makes any sense at all, because it poses the risk of creating artificial structures providing support for non-innovative businesses while important market players, namely innovation-driven businesses may have little or no interest in actively cooperating in such a cluster network, or may prefer other means of cooperation to make the best possible use of innovation potentials. The survey and analysis focused on a number of different knowledge spillover channels to obtain more certainty about the channels that are used to transmit relevant know-how and that have a direct impact on revenue growth. Since the location of a business in a cluster region may lead, as discussed, to such transmission of knowledge, corporate management was asked in the survey, among other things, to assess if the business was part of a regional cluster and if it actively participated in it. By way of distinction, businesses were also asked about specific research cooperation projects with other businesses and research institutions. Any possible knowledge spillovers caused by, for example, the availability of qualified staff of a local university were also taken into consideration. Other factors having an impact on corporate growth discussed in academic literatures, such as business size and equity ratio, which might determine the investment potential of young ICT companies, venture capital and degree of internationalization were also taken into account. The innovation capacity of a business is rated as one of the most important sources. Here a distinction was made between research and development expenditure and the actual research output. An assessment of regional policies was also included in the econometric analysis.

The analysis under consideration led to some unexpected findings. While the relevance of expenditure for R&D or the launch of a new product, a high degree of internationalization and high equity ratio, venture capital or access to capital, inverse corporate age (young businesses grow faster than older ones) and corporate size go hand-in-hand with more opportunities for strong corporate growth, the involvement in a regional cluster does not indicate any growth effect. That's not all: Every business that was described by its management as being part of a cluster and as being actively involved in it, even showed a significant negative effect on average growth during the past five years compared to companies not belonging to an ICT cluster. In summary, businesses that are not part of a cluster grow faster than businesses belonging to a cluster. This result contradicts the positive effect suggested in academic literature. It appears that in the ICT sector especially fast growing companies have no interest in joining clusters. Innovators seem to consider the monopoly rewards of their products/services as being at risk and fear imitation by competitors. It even seems that politically motivated cluster initiatives are particularly attractive for low-growth businesses.

Furthermore, the analysis shows that specific research cooperation projects concluded with one or more enterprises have a positive impact on corporate growth compared to companies that do not conclude cooperation projects. No immediate positive growth impact from cooperation projects between the interviewed companies and universities or research institutions was discernible.

1.2.2 Dynamics in ICT Cooperation Networks in Selected German ICT Clusters

The results of the analysis were the motivation looking in more detail at the cooperation behavior of ICT companies, and therefore the basis for the next study.

Research and development activities can be organized differently by companies. Research and development may take place in the own company by subcontracting or supply, or by research cooperations with other companies or research facilities. Often, research and development work are made possible by a combination of these options. Entering into research and development cooperations would be the most precarious method for this, since transfer of specific know-how to potential competitors is also consciously risked. Still, the benefits from the risk diversification may outweigh this in case of cooperation. Risk diversification is achieved through the divided development costs and higher expectations of success of the innovation project.

A network analysis is performed based on ICT patent applications in two German cluster regions. Patents with at least two applicants on each are of interest. It may be assumed that the patent applicant know each other and cooperate in research. Cologne[5] and Karlsruhe were selected as two successful ICT cluster regions on the NUTS-2 level to find out how patent cooperations develop in parallel to cluster formation over time. Is there any cooperation conduct and do dynamics actually change? Who are the most important players in cooperation networks? Furthermore, in addition to interregional cooperation relationships, cooperation networks between companies from the cluster region with at least one company outside of the region are presented. In how far are there also cooperations of entrepreneurs who use knowledge generated in the cluster region but have their main seat outside of the region in question, i.e. that "tap" the know-how in the cluster region? It should be shown whether local cooperations are actually highly present or actors outside of the region play an at least equally important role as innovation partners. Are there any parallels between the successful regions or do cooperation relationships develop differently?

Social network analysis is not a common analysis instrument in business sciences, but offers benefits as compared to other methods like knowledge production function or patenting methods, which are often used for cluster analysis, or can supplement these methods very well. It turned out that cooperation also develops dynamically in cluster development processes. In both regions, the network expanded and continued to diversify while also strengthening in its structures. This is made clear by the analysis network indices, as well as the graphic network mappings. In both regions. The overall networks show that cooperation intensity as well as the number of cooperating innovators increases. Both regions have several important innovator cooperations regarding number and intensity. Breaking apart of the cooperation networks by loss of an innovator is not a risk. Knowledge transfer between innovators into which a third innovator is integrated has also clearly increased.

[5] The NUTS-2 region Cologne includes the city of Aachen with a high innvoation output in the ICT area and density of ICT companies.

It is not surprising that the most important innovators are large companies. In particular multinational ICT companies and automotive groups are central actors in the cooperation networks. There also are some differences between the two regions here. While the overall networks develop dynamically in parallel over time, important actors in the cooperation networks are external companies. They often tap the knowledge region – i.e. they cooperate with inventors form the region but have their own corporate seat outside of the region in question. There also is a strong increase for Cologne at least in the area of cooperations between regional companies and external companies. Interregional cooperations clearly developed less dynamically in both regions.

It is interesting to note that the large multinational groups in the Karlsruhe region are often the same as those in the Cologne region. In addition to them, many research institutes are involved in the cooperations in the Karlsruhe region, or serve as knowledge intermediaries. While this is also the case in the Cologne region, Karlsruhe is extraordinarily strongly positioned here, with often more than five different research institutes as important players in the network. On the other hand, cooperating companies outside the region are not as important here for network expansion as they are in the NUTS-2 region of Cologne. Expansion of the networks therefore was driven rather by external companies in the Cologne area and by research cooperations with at least one research institute from the region as an innovator in the Karlsruhe region.

Therefore, some of the results of the previous analysis could be confirmed. Research cooperations seem to be important in the innovation process. However, cluster regions do not show increased intra-cooperation activities with companies within the region. Physical distance does not seem to be decisive for the innovation process. This gives rise to the conclusion that other factors, like low transaction costs or a specialized local labor market offer better explanations for spatial agglomeration of companies from the same sector.

1.2.3 Does the Financial System Affect Early Stage Venture Capital Investments?

The last chapter deals with another critical factor for development of innovations. The financing problem mainly affects young, innovative companies, since collateral security is hardly suitable for the digital economy or modern knowledge society due to the high specialization character and high depreciation need, in contrast to the traditional industry of the 20th century. In particular for sectors with high growth and employment potential, there may arise special barriers for the financing system as well; phrasing business-politics reform options suitable in this respect is one of the important tasks of business politics.

Joseph Schumpeter (1911) recognized in the early 20th century already that the financial markets and finance intermediaries have an essential task for facilitation of technology innovations, and thus economic growth. Among others, they serve as capital accumulation points, evaluate investment projects and their risks, affect the management and permit – under facilitation of market transactions- diversification of risk.

The early writings of Schumpeter hold a different view of innovation than the later ones, in which he saw relative innovation benefits in large companies.

Financing of innovations as compared to financing of capital goods is therefore characterized by special features that may lead to higher or additional financial restrictions. Collateral for credit is relatively difficult and innovation projects by nature show a relatively strong information asymmetry between a company active in innovation and the bank providing the loan. The expenses for innovations also have a different structure or weighting than those for investments in fixed assets. Expenses for innovation projects essentially comprise staff expenses, e.g. for research and development (R&D), construction, design, training and market introduction. Additionally, knowledge gained from research and development is often implicit, i.e. not codifiable, knowledge closely linked to the human capital of a company and partially lost if employees leave or lose their jobs. Additionally, there is a high insecurity regarding the innovation output with the objective of developing a marketable product. External creditors often demand a risk surcharge to the interest common on the market due to asymmetric information problems and moral hazard problems. On the one hand, innovation projects may fail because of this higher interest rate. On the other hand, debtors may choose higher-risk projects on purpose to achieve a higher return and thus negatively influence the risk structure.[6]

While large companies are able to comprehensively use external financing sources and in particular the stock market, financing of innovations is often difficult in particular from the point of view of small and medium-sized businesses, in particular in countries with a bank-based financing system. Additionally, building of reputation as a smaller company with strong innovation takes time. This is made more difficult because start-up companies often have a negative cash-flow in the first years, as well as a business model that is often difficult to understand for the banks and that may be an obstacle for financing.

In particular venture capital has some advantages over credit financing. The lack of collateral to secure a credit may be balanced out by corresponding participation between the entrepreneur and capital provider. Venture capital investors (VCs) usually specialize in specific industries and therefore usually have a high competence in evaluation of present risks or opportunities.[7] Often, venture capital investors are closely connected to management by holding shares. This makes it easier to influence or at least control it, and reduces the moral hazard problem. Additionally VCs provide their expertise to the portfolio company's management to increase goodwill in the medium term. VCs mediate risk capital, usually from institutional investors like pension funds, insurance companies, banks, funds of funds, etc. Institutional investors manage large amounts of assets which are well-diversified. These investors then seek additional returns and are thus willing to allocate a small fraction of their capital to riskier investments. VCs do not make an

[6] The consequence of this may be credit rationing. Stiglitz/Weiss (1981) present a model in which banks stipulate a profit-maximising interest rate that does not match the market-clearing interst rate, leading to credit demand rationing.

[7] In Germany, VC investments in the communications and computer/entertainment electronics sectors amounted to 206.73 Mio. Euro in 2010, corresponding to 31.6% of all VC investments in Germany. This makes ICT the business sector in Germany that draws the greatest share of all VC investments (BVK 2012).

investment all at once. Instead, capital is provided in stages, and the entrepreneur only receives enough funding to reach the next stage. Even if the venture capitalist decides to continue the project, he or she demands a greater participation on the part of the company. So the venture capitalist has a powerful position. The venture capitalist usually receives convertible preferred stock. Like a debt contract, preferred stock requires the company to make fixed payments to the shareholders whereas the promised payments must be made before any common shareholder gets dividend payments and this way prevents that the entrepreneur pays himself high dividends (Berlin 1998). When a venture capitalist holds the shares of a young company, which means the shares are not marketable to other investors, the venture capital investor avoids the free-rider problem. The investor is able to earn profit from its monitoring activities and reduce the information costs of moral hazard (Hubbard 2008). The VC market, especially the early stage VC market in the OECD countries is very heterogeneous in terms of the investment levels and in most countries underdeveloped compared to the US.

Therefore the last analysis in this study examines factors which could influence the relative number of early stage VC investments within different OECD countries. Early stage VC means VC which is provided at the beginning of the business cycle the so-called seed (or pre-seed) and start up phase which is critical, as very often no final product exists. This investment stage is obviously risky but provides potentially high returns in case of a successful company development. The less risky later stage VC investments which encompass expansion and replacement investments could be more attractive for VCs. So the financing gap exists especially in the start up phase. The existing literature suggests that (early stage) VC investments are strongly negatively affected by the characteristics of a bank-centered financial system and this negative influence could be one reason for different VC investment levels across the OECD countries.

The presented analysis is the first one that includes the relative size of the banking sector to produce evidence regarding whether, as is suggested in the predominant theoretical financial literature, the negative impact of a more bank-based financial system can withstand the empirical evidence The fundamental argument supplied by Black and Gilson (1998) argues that banks are not able to duplicate the implicit contract regarding future control as a market-based system can. Additionally, a more market-based system provides more lucrative exits via IPOs. Whereas markets are complements for VC, banks are to some extend substitutes. The panel analysis conducted for 16 OECD countries supports this view.

All in all, the presented essays offer new and partially surprising results. Cooperations in the innovation process are important for innovation output and growth, but physical proximity of (potential) innovators does not seem to be as essential as the corresponding literature often assumes – at least not in the ICT sector. Regarding innovating financing, counties like Germany, where companies more commonly receive credits from credit institutions, mean experience increased financing restriction for young start-ups in high-growth sectors, since VC are partially replaced by bank credits there.

2. Regional and Company-specific Factors for High Growth Dynamics of ICT Companies in Germany with Particular Emphasis on Knowledge Spillovers

JEL classification: R10, O18, L63, L86

Keywords: Regional Science, Cluster, ICT, Firm Growth, Knowledge Spillover, Spatial Spillover

Abstract: 200 ICT companies based in Germany were interviewed to find out which regional and company specific factors have a measurable direct impact on corporate growth.

The analysis found that firm age and size, export ratio, expenditure on research and development, product innovation, venture capital and concrete cooperation between companies have a direct effect on the growth of ICT companies. Surprisingly active participation in an ICT cluster has a negative impact on company growth or to be more precisely, it appears that predominant low growth ICT companies operating active in clusters.

2.1 Introduction

It is essential for developed economies to bring forth innovation-driven businesses and to promote growth opportunities for them in order to ensure sustained economic growth. Small and medium-sized companies, the traditional mainstay of the European and, in particular, the German economy, play a key role in this respect. The arguably most important technological innovations of the past decade were initiated by information and communication technology (ICT). Thus the ICT sector, compared to the overall value creation development, grew very quickly. At the same time, the implementation of ICT technology and infrastructures increased productivity in nearly all other sectors of the economy. Hence, a vital ICT sector is of great importance for Germany and is likely to enhance its international competitive position even further.

In view of the significance of ICT businesses, it is rather astonishing that there are only comparatively few studies on the specific regional and company-specific impact factors for high corporate growth dynamics. This may be due - as so often - to the dearth of data available to carry out such an analysis. At the same time, identification of factors that support the positive growth effects of ICT businesses would be of great importance in the context of a targeted economic policy. Even in a single European economic area, businesses still find themselves, due to differing national institutions and economic structures, in differing country-specific environments, which contribute to the success or failure of their economic activities. This aspect has an even greater relevance for sector-specific analyses.

To be able to make meaningful recommendations for future actions, the present analysis interviewed ICT businesses in Germany. The information gained was evaluated by means of a probit model and provides insight into regional and company-specific impact factors that are factually relevant to enhance the growth

opportunities in each specific case. More than 200 businesses returned the completed electronic questionnaire. The information submitted provides answers to the question on how, capital structure, company age and size, export activities and knowledge spillover in particular have an impact on growth dynamics. The focus is, however, on the role of various knowledge channels on company growth. Therefore, the questionnaire asked for possible sources of knowledge transfer to evaluate their effects. This means that the question was whether the company was located in a cluster region, whether it was actively cooperating with other companies and/or universities and how the access to human capital was assessed.

The motivation to deal with "knowledge spillover," the intentional or unintentional "spillover" of know-how between economic actors since this phenomenon is considered to be important for the dispersion of knowledge, in particular in innovation-driven sectors like the ICT sector. Knowledge is an entirely private good if it is incorporated in a person and associated with his or her talents. This kind of knowledge or a combination of specific resources which is not replicable is called tacit knowledge.[8] This kind of knowledge does not circulate frictionless. According to (recent) economic geography and/or location theories, spatial mobility theories and regional growth and development theories, clusters are considered to be beneficial for stimulating an exchange of (this) knowledge. Accordingly, a cluster development strategy is considered to be an important economic policy tool that is currently widely used by economic policy-makers.[9] The economic policy instrument of actively supporting networking activities between businesses on a meso-level became "fashionable" in the nineties and has been used ever since to an increasing extent by political decision-makers.

However, the positive economic effect of clusters is being critically discussed in the corresponding literature, as is shown, among others, in the next chapter. In contrast to nearly all studies, data was elaborately collected in the ICT company survey, which permits more precise analysis of knowledge spillovers. Most other studies on this subject are case studies or use the method of the knowledge production function, based on meso-level regional data. Knowledge spillovers are considered a kind of black box in these analyses, i.e. different elasticities between external and local innovation input to innovation output are interpreted as knowledge spillover. Detailed observation is hardly possible because of the data collected, and it is easily possible that other factors, such as benefits from better access to specialized human capital, are responsible for higher growth of companies in the region under

[8] For a broader discussion to the terms knowledge and tacit knowledge see Balconi et al. (2007).

[9] Policies to support clusters, generally understood to be geographic concentrations of inter-connected firms and related actors (specialised service providers, universities, etc.) A number of definitions and other terms are used by academics and policy makers to describe cluster-related phenomena and the territorial dimension of these linkages. Other terms include: industrial districts, new industrial spaces, flexible specialisation, networking, local systems of production or, for the broader environment, a regional innovation system or reduced-scale national innovation system. There is a critical debate about the definition, dimensions and value added of the cluster concept (OECD 2010, p.1). See for example Brown et al. (2010) for different cluster definitions. The concepts of cluster often encompass more than spatial proximity as organizational, social, institutional proximity or a combination of them (Boschma 2005).

observation. As compared to this, Case Studies have the disadvantage that only one or very few regions are observed. These disadvantages are avoided by the company survey. Therefore, this analysis should be a substantial contribution to evaluation of knowledge on company growth in the ICT sector. It may help to show whether this active cluster support, as currently practiced, makes any sense at all.

The analysis under consideration led to some unexpected findings. Every business that was described by its management as being part of a cluster and as being actively involved in it, even showed a significant negative effect on average growth during the past five years compared to companies not belonging to an ICT cluster. In summary, businesses that are not part of a cluster grow faster than businesses belonging to a cluster. This result contradicts the positive effect propagated in academic literature. It appears that in the ICT sector especially fast growing companies have no interest in joining clusters. Innovators seem to consider the monopoly rewards of their products/services as being at risk and fear imitation by competitors. It even seems that politically motivated cluster initiatives are particularly attractive for low-growth businesses. Furthermore, the analysis shows that specific research cooperation projects concluded with one or more enterprises have a positive impact on corporate growth compared to companies that do not conclude cooperation projects. No immediate positive growth impact from cooperation projects between the interviewed companies and universities or research institutions was discernible.

The next section gives a brief description of the related literature of selected regional and firm specific findings that have an impact on corporate growth. This will be followed by the empirical section. The analysis will end with conclusions and policy implications as well as some restrictive comments on the scope of the analysis under consideration.

2.2 Related Literature to Growth Enhancing Effects

2.2.1 Knowledge Spillover due to Spatial Proximity and Collaborations

Marshall (1920) was one of the pioneers in the academic literature who discussed geographic location as a competitive advantage for enterprises with certain features in the context of the growing importance of knowledge for developed economies. The physical proximity of cluster members increases the probability that knowledge will be disseminated via formal meetings, such as conferences, joint projects, industrial fairs, but also by means of informal gatherings of cluster members. This transmitted knowledge plays a major role in diffusing knowledge especially for innovative businesses (Armington/Acs 2002, Capello 2002).

Numerous empirical studies have shown that there might be a robust connection between clusters, knowledge spillover and the innovation output, growth perspectives or productivity of enterprises (e.g. Audretsch/Feldman 1996, Deeds et al. 1997, Baptista 2000, Ibrahim et al. 2009, Maine et al. 2010, Kesidou et al. 2009, Feser et al. 2008). Jaffe et al. (1993) discovered in respect of high-growth innovative sectors that patent citations of other patents are five to ten times more likely within one city, at least

within the first year after the patent was granted. Almeida and Kogut (1997), present similar results with regard to patent citation and, thus, emphasize the interconnectedness of innovation and spatial proximity. Enterprises established in clusters not only have a higher business output, but possibly also a higher growth of revenue (Canina et al. 2005) and survival prospects (Folta et al. 2006, Stuart/Sorensons 2003, Sorenson/Audia 2000) as well as a higher founding rate (see in this respect Van Oort /Atzema 2004 for the establishment of ICT enterprises in the Netherlands). Chung and Kanins (2001) concluded that especially small firms benefit from a local firm aggregation of already established businesses because these have already created demand externalities; thus newly-formed businesses can benefit from the large volume of customers of the older enterprises, which are also more profitable as a rule.

Especially the highly innovative products and services of the ICT sector often contain a large portion of knowledge that is not readily available and often only exists in the minds of the persons involved in the development of certain products or processes. Along the agglomeration theories one can expect: the higher this share of implicit knowledge, the more important direct communication becomes. Due to the considerable leaps in the development of information and communication technologies, clusters can no longer be analyzed only within geographic boundaries. However, due to its informal character, the person-to-person exchange of information provides certain additional advantages that should not be underestimated. The academic literature dealing with the spillover effects of implicit knowledge in clusters or in regional development (e.g., Kogut/Zander 1992, Jaffe et al. 1993, Adams/Jaffe 1996) emphasizes that this knowledge can often be gained only by direct observation, participation or joint experience. It also provides an opportunity to critically review one's own daily working practice (Maskell 2001). Spatial proximity gives rise to close personal relationships, which are often strengthened by similar cultural values.

Innovative businesses are often established in the vicinity of universities to profit from spillover effects (Audretsch/Lehmann/Warning 2003, Audretsch/Feldman 1996, Malmberg et al. 1996, Gilbert et al. 2008, Mansfield 1995). Link/Rees (1990) discovered that in particular the innovative capacity of small businesses is strengthened by collaborating with universities, while large enterprises with more than 10,000 employees cooperate comparatively more often with universities, but seem to be able to profit only to a lesser extent from the collaboration. Audretsch/Lehmann (2005), too, observed a positive correlation between growth rates (in relation to the level of employment) of German high tech enterprises and their geographic proximity to a university. However, a prerequisite was that the university produced a sufficient quantity of scientific output in the form of reviewed scientific publications. Thus, it is conceivable that the quality of the research institutions was decisive or that only enterprises within a certain size range experienced beneficial effects.

Thus, there are numerous arguments in favor of the beneficial growth impact of clusters; Silicon Valley is considered to be an incontrovertible example of the success of clusters. It is however questionable if such a unique regional composition of high-tech businesses can be replicated in other locations with the same success.

In addition to the positive effects of cluster formation as named and found in literature, there are also many critical analyses. Potter/Watts (2011) show that Marshall externalities in later life-cycle phases of an industry even negatively affect economic performance of the companies and that town regions that used to economically prosper because of an economic sector are now some of the poorest ones in Europe. Huber (2012) notes that the R&D employees working at the IT cluster in Cambridge do not think that local knowledge spillover plays any important roles. Huber believes that labour market benefits and the global "brand" of Cambridge are the decisive factors for success. Breschi and Lisioni (2001) explain the phenomenon of spatial proximity of companies rather by benefits in transaction-intense relationships between supplier and customer, and less by locally limited knowledge spillover. Malmberg/Power (2006) present many critical studies that found no proof for additional innovative cooperations from geographic agglomeration of companies. The opposite was the case, according to them, and cooperations over larger distances prevail over local cooperations (Angel/Engestrom 1995).

Other critical studies on agglomeration benefits argue that an above-average patenting frequency as cited for the cluster regions rather serves to protect own innovations against increased competition than inducing higher innovation output. Additionally, higher patenting rates of small and medium-sized companies as is has been found by Audretsch/Lehmann can be explained by company size. These companies often do not have the financial resources for their own R&D and depend on cooperations with universities. Countries and industry-specific differences should also be considered in an analysis. In addition, by reason of the available data, many studies only focus on one cluster region but different sectors. Although empirical results to the positive effect of spatial agglomberation are ambiguous, nevertheless, the following hypothesis is formulated:

ICT Enterprises that benefit from knowledge spillover have a faster growth in revenue than enterprises that use little exogenous knowledge.

This hypothesis does not limit knowledge spillover on spatial agglomeration but rules this phenomen not out. According to that the analysis in the next section considers different knowlege channels.

Other possible relevant growth factors that are considered

In the following, other aspects are included that the author believes important in addition to possible knowledge spillovers and that may influence company performance of ICT companies. Literature offers many research contributions on financing problems, company age or size here. Below these items are analysed and discussed in more detail, as are other possibly relevant aspects. Apart from this, limitations are stated and it is clarified which possible factors were not considered.

2.2.2 Funding

An ICT enterprise or the underlying business model, is often not readily transparent for outsiders, unless technically well-versed. The entrepreneur may not reveal all risks resulting from the business model, but

will rather seek to emphasize its opportunities. This asymmetrical information problem (Stiglitz/Weiss 1981), in combination with the rapidly dwindling collateral value of hardware components over time, presents in particular for inexperienced entrepreneurs an obstacle to obtain investment capital.

For many ICT enterprises the basic rule applies: high entry costs may be incurred, while the marginal costs, especially for software businesses, are often very low. It is typical for ICT enterprises that the network effect leads to economies of scale on the demand side. If the new network is in strong demand, this is initially a beneficial effect; however, in case of investment capital funding, there is a risk that not enough capital to ensure an optimal future growth will be provided (Hyytinen/Pajarinen, 2004). If the network fails, the young enterprise is likely to disappear from the market. The increased risk for young ICT enterprises cannot be readily compensated by a higher loan interest rate. From the perspective of the lending bank, the quality of its credit portfolio deteriorates with increasing interest rates because enterprises with a stable, but less profitable business model will withdraw, while higher-risk enterprises will be added (Stiglitz/Weiss 1981, Winker 1999). The interest rate at which the banks maximize their profits may be below the market interest rate, which in turn has a detrimental impact on high-risk ICT investments. As a result, innovations are often only funded by internal means or equity. Hall (1992) revealed a positive and significant correlation between the elasticity of investments in research and development and the cash flow of US enterprises in the processing trade. But using internal funds for financing innovation requires the existence of such funds. This is rarely the case, especially for young businesses, and young start-up businesses often generate a negative cash flow in initial years until their product has reached market maturity. With regard to SMEs in Germany, Czarnitzki/Hottenrott (2011) show that internal financing shortfalls have a more significant impact on R&D investments than on fixed asset investments. Even in the case of successful R&D activities, meaning the generation of new knowledge, absorption of investment profits is far from being certain due to unintended positive external effects. European patent law is more liberal than US law, in particular with regard to ICT, meaning that it is more difficult to assert a patent on an ICT product at the European Patent Office than in the USA. While this may lead to more innovation, it hampers at the same time access to funding due to the reduced value of available securities for loans.

Investors providing venture capital, "venture capitalists" (VCs) usually specialize in certain industries; their experience in these industries allows them as a rule to appropriately assess any existing risks. VCs often link their participation narrowly to the management of the business. This circumstance makes it easier to influence or at least to monitor the management of the business and, thus, reduces the "moral hazard problem." Moreover, in addition to capital, VCs also provide management expertise and networks; the added value gained from such expertise and networks should not be underestimated. According to the statements, the empirical results were to confirm the following characteristics of quickly growing ICT companies: *ICT enterprises with VC funding should grow faster than enterprises without VC due to the additional know-how and networks. Furthermore, ICT enterprises with a high equity ratio grow faster than ICT enterprises with a high debt ratio.*

2.2.3 Size

In 1931, Robert Gibrat (1931) postulated that the distribution of opportunities for growth was largely independent of the actual size of the business. Gibrat departed from the assumption that growth was determined in particular by making use of opportunities that are available to every enterprise. According to Gibrat, these opportunities are normally distributed, i.e., that they occur for each enterprise with the same frequency. Thus, growth opportunities behave proportionally to the actual size of the enterprise. Thus, every enterprise will double its turnover within a defined period of time with the same probability, irrespective of its current turnover level. Gibrat based his theory on own empirical studies. The following studies initially confirmed these findings. However, at the time only statistical data of very large enterprises (with reference to their turnover) were available for the econometric examinations. Mansfield (1962) and Evans (1987), among others, showed by including younger enterprises that the analytical-logical deductions of Gibrat's model could not be confirmed without reservation. They illustrate that smaller and younger enterprises have a lower probability of survival. Furthermore, small, innovative enterprises grow disproportionally faster in comparison to larger, innovative enterprises. This may be due to the higher degree of diversification opportunities with regard to the products and/or business fields available to larger enterprises. Their more widespread positioning may prevent larger growth rates, but offer on the other hand higher chance of survival in the event of an external shock. Jovanovic (1982) provides an additional explanation for this phenomenon by means of a theoretical model. Jovanovic models the negative correlation by varying production costs on the basis of varying learning effects over time. Enterprises that learn to produce more efficiently over time will survive and grow disproportionately, while inefficient ones will be driven out of the market

Audretsch et al. (2004) in turn, established that Gibrat's law applies to service enterprises in the gastronomy sector.[10] The reason why Gibrat's law does not apply to the entire processing industry, but only to some sectors and to large portions of the services sector, is due, according to Audretsch et al., to the discrepancy between the two assumptions, on which the law is based. The first assumption is that the next "favorable opportunity" for higher growth behaves proportionally to the current size of a business or will develop evenly along the time axis; however, this assumption does not necessarily lead to the second assumption that corporate growth is independent on the size of the enterprise. An important restriction is that such an assumption is only permissible if there is no correlation between the size of an enterprise and its probability of survival. Audretsch et al. argue that as soon as the survival probability correlates positively with the size of the enterprise, the assumption of a normal distribution of the growth opportunities across the board for all enterprises no longer applies. It is likely that negative growth will less often cause larger enterprises to disappear from the market than small enterprises. This bias leads to the result described above, namely that Gibrat's law applies to large enterprises, since they are more likely

[10] See Santarelli et al. (2006), for a comprehensive overview of the empirical literature on Gibrat´s law. In addition, a comprehensive and systematic compilation of all empirical studies on the topic of growth of enterprises is presented; for more recent studies as of 2001, see Cassia/Colombelli 2010.

to survive negative growth over a certain period of time than smaller enterprises. Because the survival probability of enterprises differs in the various industry sectors, this effect has at the same time a more or less significant impact on the correlation between business size and growth. Numerous studies show that economic sectors in which capital intensity, economies of scale and "sunk costs" are low, a distortion of survival probabilities to the disadvantage of smaller enterprises is hardly apparent; accordingly, in these sectors there is no correlation between growth and business size (Audretsch et al. 2004). However, since these factors often occur in the ICT sector, one should expect: *Smaller and younger ICT enterprises grow faster over time than large ICT enterprises.*

2.2.4 Other

According to Wagner (2002), businesses that export show a significantly higher growth also with regard to employment. Wagner compares German exporting businesses in the processing sector to non-exporting "twin businesses" over a certain observation period. A positive correlation between export intensity and corporate growth is to be expected for ICT businesses since economies of scale play an important role in this sector.

The analysis considers also the local tax rate. A lower tax rate means a comparatively higher cash flow. Since cash flow, as described above, plays an important role in providing funding for innovative enterprises, it is conducive to growth; accordingly, a negative correlation between the tax rate and corporate growth may possibly exist.

The analysis also placed emphasis on regional policies. The basic assumption is that corporate decision-makers rate the performance of local policy-makers in certain regions better than in other regions. Such a positive or negative assessment with regard to ICT location policy might also relate to growth dynamics.

Another aspect that is also at the focus of current political debate is the current lack of specialists that is often considered an obstacle for higher growth. In particular the ICT sector is affected by this lack of specialists, the companies asked therefore were supposed to assess how hard or easy acquisition of specialists was for them.

Of course, there are also factors not named in this chapter that influence company growth and provide interesting fields for examination. Personal characteristics of the company founder or manager are one potential factor for this, and have often been discussed in literature. Although the odd study may have failed to establish such a relationship there is also compelling evidence that the owner-manager's growth motivation, communicated vision and goals have direct effects on the firm's growth (Davidson et al. 2007, p.365). However, the length of a questionnaire negatively affects return rates. Therefore, some aspects were (deliberately) left out to take into consideration the trade-off between number of observations and scope of examination. Personal characteristics of the entrepreneur or management would even have required a relatively high number of further questions. However, important potential growth

determinators are expected to have been considered in spite of these limitations, leaving enough space for interesting results

2.3 Empirical Analysis of Selected (Potential) Growth Determinants of ICT Firms in Germany

The information on the companies questioned are taken from the Hoppenstedt database. Search criteria entered are WZ 2008 telecommunications (61), rendering of information technology services (62), information services (63) and the character of a private-sector form of companies. Out of the approx. 14,000 companies that are listed alphabetically sorted, about every third company was contacted. This leads to a total of approx. 5000 questioned companies from the private sector. The respective email addresses were also taken from the Hoppenstedt database. Approx. 10% of the email addresses were no longer up to date, so that about 4500 companies were actually contacted. The letter and questionnaire were targeted at the management. The companies were not selected by size, geographic distribution, age, etc., so that this is a representative sample of surviving ICT companies with a German internet address. The questionnaire was addressed to the management. 213 Company representatives returned a questionnaire. The varying number of observations (see also statistical information on the responses in the appendix) that was indicated for every presented estimate shows that not all 213 companies answered all the questions.The survey was conducted at the end of 2009/beginning of 2010.

To obtain a higher return rate, the answer options were divided into categories so that management only had to check the corresponding category. Therefore, an ordered probit model was used for the econometric analysis.

2.3.1 Model

$y_{it} = X_{it} + \varepsilon_{it}$

$$y_{salesgrowth} = \begin{cases} 0 \text{ if } y = \text{no sales growth or negative growth} \\ 1 \text{ if } y > 0 \leq 5\ \% \text{ sales growth} \\ 2 \text{ if } y > 5 \leq 10\ \% \text{ sales growth} \\ 3 \text{ if } y > 10 \leq 20\% \text{ sales growth} \\ 4 \text{ if } y > 20\ \% \text{ sales growth} \end{cases}$$

y is the variable to be explained and classifies the average annual corporate growth of the interviewed enterprise during the past five years.

X_{it}' is a vector of i exogenous variables for point in time t and ε_{it} is an error term. As already explained, categories were also formed for a large portion of the exogenous variables. Since the returned questionnaires did not provide sufficient statistical data for all answer categories, these were consolidated

as far as this was meaningful. The used variables or rather the actually used divisions are described below and in the appendix with an indication of the actually provided number of answers.

2.3.2 Descriptive Statistics

Numerous variants of the above model were assessed. For the sake of clarity, 11 variants or estimates were listed (see appendix). In each model, the revenue increase was expressed by reference to the number of employees and the age of the enterprise as well as by reference to the control variables of the local tax (municipal multiplier) rate and export ratio or export intensity. To examine the hypothesis stated above, various proxies were used for the degree of innovation and spillover effects. This means specifically that the interviewed enterprises took R&D expenditure or intensity in relation to corporate turnover and the type of generated innovations into account. The following innovation types were distinguished: entirely new product; improvement of an existing product, introduction of a new technology, which changed the production of an existing product substantially and organizational improvement. If the enterprise engaged in innovative activities it had the option to indicate by means of multiple responses the types of innovations generated during the previous three years. These data were included as a rule in the analysis; however, for the sake of clarity, data that did not provide statistically significant results were omitted. To come to the point, it can be said, as was to be expected, that the introduction of a new product has a positive and significant impact on corporate growth. The other referenced innovation types do not have a direct, measurable impact on growth dynamics and, therefore, were omitted from the overview of results.

Various potential spillover channels for knowledge transfer were included in the analysis. This was a focal point in the analysis of clusters. To this end, the management of the interviewed enterprises was asked to respond to the following question:

Is your enterprise an actor in a regional economic cluster? The term cluster is used to denote networks of closely cooperating businesses that are located in spatial proximity to each other and whose activities complement each other along one or more value chains or that are related to each other. Are there other enterprises from your industry and in your vicinity with which your enterprise maintains a close economic cooperation?

a) Yes b) No

Is the enterprise, according to your perception, an active participant in this cluster? Please provide your assessment on a scale of 1 to 5.

1) Very active 2) Active 3) Neutral 4) Not very active 5) Not active

Here too, the categories were consolidated to provide a higher and, thus, more balanced number of observations for each class. Responses 1 and 2 are assessed as active participants, while responses 4 and 5 are grouped as non-active cluster members. Furthermore, on the basis of the data of the European Cluster Observatory and of the Initiative Networks of Competence of the BMWi (2010) it was examined if these businesses were actually located in a cluster structure or if this was merely the subjective perception of the

business's management without meeting objective criteria. In doing so, a very high degree of data coincidence was observed. The advantage of the data, which are made available to ICT networks by the BMWi, is that they relate to clusters that are not very young anymore. This means that the cluster has reached a certain minimum size and that the networking partners have already fulfilled essential admission criteria. Thus, the requirements for a "functioning" cluster are met. In addition to the existence of a critical number of ICT businesses in the region, there are also cooperation projects between enterprises and research institutions. Furthermore, cluster management ensures a better coordination of the cooperation and provides support in establishing contact among cluster members as well as in external marketing. Only enterprises which indicated in their questionnaires that they were active members of a cluster were included in the probit assessment with 1 (otherwise 0); subsequently the numbers were adjusted to include only enterprises located in cities or towns that belong to the Initiative "Networks for Competence Germany:" Three conditions had to be met at once to assess a company questioned as "Active in a Cluster": The question of whether the company was a cluster member had to be answered with yes. Additionally, the question: Is the company, in their own perception, an active participant in this cluster? Please rate on a scale from 1 to 5 had to be at least 1 or 2. The third condition also had to be met: The company questioned had to be located in a region promoted by the cluster initiative "Network for Competence Germany".[11]

Furthermore, in the course of the survey, the question was asked if the enterprise had concluded a specific research cooperation project. If yes, a distinction was then made between cooperation projects among enterprises and with universities or research institutions. Each enterprise located in a city or county that also harbored a university or university of applied science, a dummy variable was allocated with the value 1. Only universities or universities of applied science that offered a graduate course with high relevance for the ICT enterprise were taken into account. These included (applied) computer science, automation, electrical and electronic engineering, information technology, communications technology, embedded system engineering and mechatronics. The enterprises were to benefit from an improved access to qualified human capital and research results. An assessment of how good or how bad the access to work force was, was asked under a separate heading and, thus, was also included in the econometric analysis.

In addition, the incidence of (ICT) enterprises as well as the relative size of the ICT sector (in relation to the employment rate and number of ICT enterprises) in the region of the interviewed enterprise were included to check for possible Marshall-Arrow-Romer (MAR) and/or Jacobs spillover externalities (Gorter/Kok 2009, Carlino 2001), which might be caused by an increasing number of (ICT) businesses. Moreover, with the help of the Herfindahl Index it was established if the interviewed company was located in a homogeneous or a heterogeneous economic region. Coming to the point, it can also be stated that these variables had no significant impact so that for the sake of clarity these assessments were not differentiated in the summary of the results (table 2.3).

[11] For a map and further information to the initiative see http://www.kompetenznetze.de/netzwerke (accessed on March 2012).

A high level of own cash or equity resources make a business more independent. Innovation projects that would have to be "approved" in case of investment capital funding can be carried out without further ado. This increased flexibility may present a temporal advantage in the innovation contest with competing market participants. It is also to be assumed that enterprises with a high equity capital ratio have higher growth perspectives than ICT companies with a high total debt to equity ratio. Equity capital in the form of venture capital increases this effect due to the additional know-how of the venture capital company. Though the enterprises included in this analysis have indicated that the participation of one (or more) venture capital company(/ies) provided an added value for their company, the argument that venture capital investors only invest in high-growth enterprises cannot be dismissed entirely and should be included in the results analysis with regard to assertation formulated above, i.e. that the participation of a VC is conducive to growth.

Table 2.1 Descriptive Statistics (see Appendix)

2.3.3 Results

Attached are the assessments conducted with the above-mentioned variables in a(n) (ordered) probit model.

Table 2.2 Estimation Results (see Appendix)

This or rather the following summary reveal some interesting observations. According to the assumption, the age of a business seems to have a negative and strongly significant impact on the prospects for high growth dynamics of each enterprise concerned. The number of employees, in other words a proxy for the size of the concerned enterprise, seems to have a high, significantly positive effect on the prospects for a high revenue growth. This is not a matter of course since the correlation between business age and business size will be usually positive and high. This leads to the assumption that ICT enterprises can be broadly grouped into two categories. On the one hand, there are young, dynamic businesses with a relatively high number of employees and, on the other hand, older businesses with rather low growth dynamics. If a marketable product is placed on the market, the prospects for increased sales will be enhanced, which is hardly surprising. Other surveyed innovations, such as organizational improvements, do not reveal any direct impact on growth. This is a hardly surprising fact since organizational improvements, for example, take place on a continuous basis and rather relate to cost reductions instead of having a direct impact on growth. The degree of internationalization of the enterprises, on the other hand, has a measurable positive significant impact. Increased export activity, measured as a ratio of domestic turnover to foreign turnover, increases the chance that an enterprise will find itself in a higher growth rate category.

Table 2.3 Summary of the Results of the Ordered Probit Estimations[12]

	Corporate Growth Impact Factors	Number of Observations	Impact/Significance*
Spillover Channels	**Actively involved in a cluster**	**186**	**-****
	Cooperation with businesses	**186**	**+****
	Cooperation with universities	186	0
	(ICT) Business or employment density	186	0
	University town	186	0
	Access to human capital	181	0
	Venture capital	**186**	**+*****
	R&D	**186**	**+*****
	New product(s)	**175**	**+***
	Equity ratio	**160**	**+*****
	Regional policy	175	0
Controls	**Business age**	**186**	**-*****
	Number of employees	**186**	**+*****
	Tax (municipal multiplier) rate	186	0
	Export ratio	**186**	**+****

* Significance level of 5-10% of the Z-value in the corresponding statistical test

** Significance level of 1-5% of the Z-value in the corresponding statistical test

*** Significance level of up to 1% of the Z-value in the corresponding statistical test

More surprising is the result for enterprises that are part of a cluster structure. The assessment relates to enterprises that stated that they were part of a cluster and, moreover, that they actively participated in the cluster. An initial analysis provided the surprising result that there is a significant negative correlation between enterprises that consider themselves to be an active member of a cluster and their growth dynamics.

A higher ICT business density per se did not result in an increased short run growth dynamics rate.[13] Interestingly enough, this changes as soon as a specific cooperation was entered into with another

[12] For a comprehensive overview of the results of the estimates, see appendix 2.

[13] No significant effect resulted, as already mentioned, from the inclusion of the spread of enterprises and employment across all sectors in the analysis, to identify any Jacobs externalities, which arise from a conglomeration of various industries.

enterprise. Cooperation with other businesses significantly increases the prospects for higher growth dynamics. This same effect could not be measured for cooperation projects with universities and/or research institutions. Also whether the enterprise is located in a university town, with a university or university of applied sciences, offering courses of study that are of relevance to ICT enterprises, does not seem to constitute a criterion for increased corporate growth prospects, compared to ICT enterprises situated in locations without a university or a university of applied sciences. Though nearly 40% of the interviewees responded that the availability of qualified employees was deemed to be a critical or even very critical aspect in relation to the needs of their own enterprise, no significant immediate correlation with corporate growth was discernible. The assessment of regional economic policies also did not provide any direct, measurable effect.

Of the interviewed enterprises that returned the questionnaire, 33 had obtained VC financing. 25 of these enterprises stated that the participation of the VC provided an additional added value to the business. These businesses are very likely to show a faster growth in revenue than businesses that did not receive VC financing. Data show in addition that numerous businesses had benefitted from VC participation a considerable time ago and that the growth dynamics remained high also after the end of the participation. The obtained data also show that the prospects for a high growth dynamics rate increases with an increasing equity capital ratio. A relatively high correlation between these data and a high equity capital ratio was observed, which is hardly remarkable. Even if the result is not listed separately, a significant positive correlation between high growth dynamics and enterprises stating that they have good or very good access to capital was established. The question of causality, in other words, if higher corporate growth leads to a higher equity capital ratio or vice versa, could not be definitely answered on the basis of the surveyed cross-sectional data or on the basis of the obtained data. In addition, the data under consideration indicate that lacking financing opportunities present a growth obstacle for ICT enterprises. Nearly 28% of the interviewed businesses stated that they failed to obtain sufficient capital for necessary investments.

2.3.4 Discussion of the Results and Limitations

The results of the estimates performed cover the heterogeneous results on (local) knowledge spillovers as they can be found in literature. Knowledge spillover in cluster regions leading to more growth is not confirmed by this study. Rather, low-growth ICT companies are more frequent in cluster regions.

However, cooperation with other innovative companies seems to be important for growth. This supports the thesis of many essays according to which spatial proximity is hardly important for knowledge transfer. Cooperation is important but seems to be more likely with partners from outside the regions. Breschi/Lissoni (2001) and Angel/Engestrom (1995) have come to similar results here.

This leads to the important political implication that any present cluster organisations are to consider networking of local companies, in particular also with companies outside of the region, in their networking strategies and to include large multinational companies as technological gatekeepers.

Cooperation with universities not having any directly documentable influence on growth expectations is not really surprising. Universities often engage in basic research and are naturally characterised differently than cooperations between companies. The objective of developing products as ready for the market as possible would be rather a background matter for cooperation with research facilities. If at all, it is expected to affect long-term performance of company dynamics. Additionally, research facilities quality hardly plays any role. Additionally, the quality of research facilities may be important. As Mansfield and Lee (1996) find out that the most important contributors for product development are those with excellent research quality but this is not homogenous across disciplinary fields and depends on whether research is more basic or application-oriented (D´Este/Iammarino 2010). Concerning research cooperation between universities and companies one could expect that the research quality and the scale of R&D activities are relevant factors in explaining the probability of the amount of collaborations (D´Este/Iammarino 2010, Mansfield/Lee 1996). Since universities do not engage in quality control, final assessment of the role of research facilities on the growth process of cooperating ICT companies is not possible. In their analysis using interviews with German top researchers, Schiller/Diez (2010) provide indications according to which spatial distance is not relevant for cooperation between companies and researchers.

One item that may also be viewed critically is the fact that the age of a cluster was not included in the considerations. Cluster life cycle leads to the possibility that clusters develop "backwards" after reaching a certain age. In this case, they may even influence the growth expectations of a region negatively. However, the ICT industry is not a very old economy sector yet, so that it can be assumed that this factor is not of any essential importance of the analysis performed here.

It was clearly confirmed that innovative companies with high R&D expenses also grow more quickly. This applies particularly when the R&D expenses lead to a new product. As already noted, organisational improvements, which are performed continually, could not be identified as driver of growth in this questionnaire. On the one hand, process optimisation often leads to cost reduction or efficiency increases due to organisational improvements and do not automatically lead to turnover increase. On the other hand, it would be generally difficult to measure the influence of organizational improvements in the scope of a questionnaire. There is likely to be the problem of distorted perception of reality by the management asked. Smallest organisational innovations may be overestimated because they are often impossible to measure and every management wants to be perceived as innovative.

The above assumption according to which young companies grow more quickly could also be confirmed. While only companies were considered that are still part of the competitive environment, we know that innovative companies leave the market more often because their business models tend to come with a

higher risk. This means that the assumption of Gibrat, according to which all companies grow at the same speed at all times is not generally valid. The assumption of standard distribution regarding company age is violated for innovative companies, which the ICT sector is part of. While Audretsch et al. show that Gibrat's law applies for companies with low capital intensity, economies of scale and sunk cost this study shows that it is not applicable for the ICT sector, where these three characteristics are very important.

In this place, it should also be mentioned again that a cross-sectional analysis almost never can entirely exclude the problem of reverse causality, so that the results are rather descriptive in nature. This is shown in particular in the questions on financing of companies. Is high growth permitted by high equity or is high equity a result of high growth? I can only refer to the many empirical results that have identified high positive cash flow as an indicator for innovation expenses (Czarnitzki/Hottenrott 2011, Bloch 2005, Hall 2002). Results of the community innovation survey 2008 also confirm that innovative companies find it hard to take up loan capital, it can therefore be assumed that a high equity share leads to higher growth or is a prerequisite.

The statement on taxation should also be made more relative here. This is about a local tax rate. Its assessment rates are only part of the tax burden. Also, all companies were included, even though the assessment rate is calculated on a pro-rate basis regarding all subsidiaries in Germany, rather than only the subsidiary on site. This may distort results if the questioned companies have subsidiaries.

The results show that the importance of spatial proximity for the innovation process should not be overestimated or that its importance has been reduced over time, due to better ICT technology for information transmission. More precise analysis of the quantity development of knowledge cooperations between partners in spatial proximity and cooperations between companies located far apart could provide interesting indications in this respect. Sector-specific observation across an extended period would be sensible. If a physically decentralized development of cooperations became apparent, this would have clear implications for cluster policy or would continue to decrease their spatial effects over time.

Lack of specialists, a problem often cited by politics, could not be found. At least the variable access to human capital shows no significance.

2.4 Conclusions

Dynamically growing ICT businesses are of vital importance for the entire German economy. The analysis under consideration examined potential growth determinants on the basis of approx. 200 enterprises to obtain more information about the dynamic growth of German ICT businesses. The data collected with great care and effort by means of an electronic questionnaire produced in part interesting results. The survey focused in particular on establishing company-specific and regional factors that had a positive impact on the growth of German ICT businesses. The findings show that research and development activities, the generation of new products, a high equity capital ratio, a high level of export activities and

specific cooperation projects with other businesses are characteristic for comparatively fast-growing enterprises in the ICT sector. The same applies to companies with venture capital financing. Growth dynamics behave conversely to the age of a business, meaning that young businesses grow faster than older ones. Since only businesses that "survived" were interviewed, these results may be distorted by a higher market exit rate of younger businesses and must accordingly be put into perspective with regard to their significance. Initially surprising were however the empirical results for businesses in a cluster. Even though they do not coincide at first glance with the commonly alleged positive effects of clusters, the results are not particularly astounding at second glance. The finding that businesses, which consider themselves to be part of a cluster and which have their registered seat in a region that was designated by the BMWi networking initiative, have significantly lower growth expectations permits the assumption that high-growth businesses are hardly interested in becoming actively involved in a cluster since it puts their monopoly profits or competitive advantages at risk. These businesses focus on specific research and development cooperation projects. The interpretation of this result could be that fast growing firms seek to avoid a drain of implicit technical knowledge by an opening or active involvement in the cluster since there is no evident necessity for it. On the other hand, low-growth businesses have an interest to become involved in a cluster to increase their survival prospects. The result illustrates that the structure of artificially induced networks could unintentionally tends to attract low-growth enterprises, while the integration of successful business, on the other hand, is difficult even though the attraction of successful companies is the objective of public networking policies in order to achieve growth-inducing effects. The findings confirm that (initiated) ICT clusters in Germany only serve to a limited extent as locations for enhanced diffusion of knowledge since highly innovative and high-growth enterprises will rarely be induced to become actively involved in a cluster. The Dutch region of Eindhoven may serve as an example of positive exception. Philips, as an important I(C)T enterprise, voluntarily disclosed know-how and, thus, contributed significantly to the positive development of the local ICT cluster.

It must also be kept in mind that according to Porter the term cluster must not be used synonymously with specific networks established between economic agents, but rather describes a diffuse and creative atmosphere that has an innovative impact on the businesses established in a particular region. Indirect impacts, for example, on other businesses in a cluster could not be included in the scope of this study. As a consequence of a concentration of businesses, the mere geographic proximity will improve the chances for "coming across" potential future cooperation partners. One of the findings of this study is that specific cooperation agreements concluded between ICT enterprises with regard to R&D lead to improved prospects for corporate growth.

Of course, the analysis under consideration did not take all factors that may have a potential impact on growth into account. For example, the individual qualities of an entrepreneur of corporate managers were not taken into consideration. Their skills and personalities, corporate philosophy, the ability to promptly respond to customer needs or to changed circumstances in the competitive situation, marketing activities and anticipating new technological trends are factors determining the success of a business venture. And

finally, the coordination and activation of potentials are important determinants for success, which remained outside the scope of this analysis.

On the other hand, it was possible to identify some characteristic features of successful German ICT enterprises by means of very carefully collected data. The results of this study may motivate further sector-specific analyses, in particular with regard to the phenomenon of business agglomerations. Different behavioral patterns apply in the various industrial sectors and economic policy-makers should anticipate them in order to respond successfully.

3. Dynamics in ICT Cooperation Networks in Selected German ICT Clusters

JEL classification: R10, O18, L63, L86

Keywords: Regional Science, Cluster, ICT, Knowledge Spillover, Cooperation Networks, Innovation Networks

Abstract: High innovation capability is indispensable for generating economic growth in developed economies. Cooperations in the innovation process are entered into by companies for reasons of risk diversification or costs and often considered to be an efficient strategy to increase a company's knowledge basis. Regional economic literature very often believes that regional agglomeration of companies, i.e. cluster formation, will also lead to increased local networking, i.e. also to cooperations between companies or between company and research institutes in the innovation process.

A network analysis of the two German ICT regions performed with patent data was able to show that cluster formation coincides with a dynamic increase of cooperations measured by joint patent applications. However, the cooperations are characterized by integration of extra-regional companies and research institutes rather than being intraregional.

3.1 Introduction

Cluster promotion has been a frequently used business-politics instrument for promotion of regional economy. The term of "cluster" is used as meaning a spatial agglomeration of companies from the same economic sector along the value-added chain in this analysis. They are supplemented by the corresponding complementary companies or facilities, such as specialist suppliers and research facilities. The members are connected via supply or competitor relationships or joint interests. This analysis has a close look at the two clusters of information and communications technology (ICT) in the NUTS-2 regions of Cologne and Karlsruhe in Germany. Both regions are strong in ICT.

The idea is that spatial agglomeration permits generation of competitive advantages. These competitive advantages are created by increased competition, improved access to resources for the companies – in addition to natural resources, e.g. via a pool of specialized human capital and specialized suppliers. Additionally, synergies may result from joint use of infrastructure. A higher number of spin-offs from present companies are expected. The geographic proximity of many companies form the same economic sector leads to voluntary and involuntary, formal and informal channels that stimulate knowledge transfer in particular between companies in the cluster region – as large parts of the corresponding literature claim.

In developed economies or high-tech sectors, this so-called knowledge spillover is supposed to play an

important role in regional and general economic growth. [14] According to that the idea of knowledge spillovers is the basic concept of the endogenous growth theory and plays a key role in explaining economic growth (see e.g., Romer 1986, Aghion/Howitt 1992, 1997, Howitt/Aghion 1998, Peretto 1998, 1999a, 1999b, Schmitz 1989). The endogenous growth theory highlights unintended knowledge spillovers, which means that business, in spite of patent protection, cannot fully contain the newly acquired knowledge. Since new knowledge cannot be protected comprehensively, other companies that do not conduct R&D will also benefit. These spillovers in addition to public knowledge created by universities and public research institutes, generate constant marginal yields on the macroeconomic level are generated. Lukas (1988) advances similar arguments, but emphasizes investments into human capital. The latter increase productivity by gaining new knowledge, which is then transferred involuntarily to other economic agents, who are also able to work more productively. Along this view knowledge is a public good as it is created by one or more individuals and can be exploited by another without compensation. Nelson (1990) weakens this view and creates the term latent public good. The transfer of knowledge from an inventor to an imitator needs the capacity to absorb this knowledge. The imitator has also to invest in resources to apply the new knowledge (Cohen and Levinthal 1990). Therefore the incentive to invest in R&D may remain unaffected or is only less disturbed (Cantner et al. 2009).

Knowledge is a wholly private good if it is incorporated in a person and associated with his talents. This kind of knowledge or a combination of specific resources which is not replicable is called tacit knowledge. Hence one can argue that knowledge as a good is in terms of exclusivity and rivalry neither a typically private nor public good and should be considered differentiatedly in this regard.

Undesired knowledge outflow is countered by intended or desired knowledge spillovers between different companies, as well as between companies and research facilities. Cooperations permit exchange or joint development, in particular of complementary knowledge to achieve a more valuable and higher innovation output. Politics try to stimulate this networking as an important way of cluster promotion. Simply said, the idea is that high company density also offers a good situation for cooperations. To put this idea into practice and to network companies among each other, cluster managements have been installed and promoted in the corresponding regions. The objective is increasing local knowledge spillover and therefore also regional innovation power.

The following analysis forms the actual cooperation conduct – intended exchange of knowledge - in research and development activities in the timeline of successful ICT clusters. Is there any cooperative behavior and do dynamics actually change? Who are the important players in cooperation networks? Furthermore, in addition to intra-regional cooperation relationships, cooperation networks are also developed between companies from the cluster region and at least one company outside of the region. In how far are there also cooperations between companies that use knowledge generated in the cluster region but are headquartered outside of the region under consideration? These companies "tap" the knowledge in

[14] Along with Döring/Schnellenbach (2006) this paper understands knowledge as comprising all cognitions and abilities that individuals use to solve problems, make decisions and understand incoming information.

the cluster region. The analysis is to show whether there is actually a large number of local cooperations or whether actors outside of the region are at least as important as innovation partners. Are there any parallels between the successful regions or do cooperation relationships develop very differently?

To add a new component to empiric literature and to gain new insights on the cooperation behavior in the innovation process in clusters, the cooperation conduct of patent applicants in the ICT sector in two German regions, the NUTS-2 region of Cologne and the NUTS-2 region of Karlsruhe. The ICT sector was chosen because it is one of the most important business sectors in Germany. On the one hand, the ICT sector has a high growth and innovation dynamic. On the other hand, it is considered an important cross-section technology. This means that ICT increases production efficiency in nearly all other business sectors. The selected regions show above-average ICT knowledge, i.e. a high number of ICT patent applications.

The analysis instrument used is the method of network analysis, as already mentioned. This way, changes in the number of joint patent applications and networking patterns between the cooperating cluster participants can be illustrated and observed in more detail by networking analysis measures. Network analysis is an instrument that is not very common yet in business sciences but used increasingly often for analysis of innovation systems or cluster analyses (see, e.g., the studies by Welfens 2011, Emons 2011, He/Fallah 2009, Graf/Henning 2009, Cantner et al. 2009, Giuliani 2005), because it is very well suitable for visualization of knowledge channels and has some benefits over the previous analysis methods, such as the often-applied concept of the knowledge production function. Two observation periods each are chosen – 10 years before founding of a cluster management in the region and 10 years after.

The following is a brief but also critical treatment of the economic effect of knowledge flows in clusters, i.e. local knowledge spillovers. Existing theoretic and empiric literature on this subject is used as a basis for discussion of how external knowledge influx into the cluster region may play a role, and under what prerequisites companies cooperate in research and development. The third section is targeted at performance of a network analysis of cooperating companies. Business politics implications and further research demand, as well as limitations of this study are phrased in section four of this chapter.

The results show that a successful cluster region shows dynamic development of cooperations. The cooperation networks expand. However, each of the two regions also has some specific features in cooperation conduct. While cooperations with external companies, e.g. at least one registering party on the patent being headquartered outside of the region under consideration, seems important for Cologne, research institutions play a very important role as knowledge intermediaries in Karlsruhe.

In both regions it can be noted that intraregional cooperations between companies have hardly increased and that stronger networking over time is not evident.

3.2 Cluster, Knowledge Spillover and Cooperation

3.2.1 The Role of Clusters and (Local) Knowledge Spillovers for Regional Growth

Alfred Marshall (1920) was probably the first person to emphasize the phenomenon of cluster formation and the concurrent agglomeration benefits. In particular Porter (1990) revitalized the concept in a globalizing economy by further aspects or increased consciousness for so-called knowledge spillovers created by increased spatial collection of business subjects, deriving competitive advantages for these regions. Exogenic knowledge is highly important for the internal innovation process. Innovation is based on the combination or recombination of former knowledge (Schumpeter 1911, Cantner et al. 2009). The creation of new technological knowledge means a cumulative learning process which underlies mainly two components. By the idiosyncratic component the innovator learns through his own experience and knowledge accumulation up to now. The second component means the influence through external factors as the experience and know how of other innovators (Cantner et al. 2009, p.202).

A high company density therefore should also coincide with high know-how spillover effects (Griliches 1992, Jaffe et al. 1993), and generate so-called Marshall-Arrow-Romer knowledge externalities that increase the companies' abilities to develop innovations. This is supposed to additionally stimulate productiveness and growth of the companies or the region. Empiric cluster research has since tried to document the positive effects regarding innovation output and/or innovation inputs (e.g. Baptista/Swann 1998, Beaudry/Breschi 2003, Falck et al. 2010), productiveness (e.g. Engelsoft et al. 2006, Fontagné et al. 2010), newly founded companies (e.g. McDonald et al. 2006, Delgado et al. 2010) and growth of companies and employment (e.g. Tomokazu et al. 2006, Feser et al. 2008, Hafner 2008, Maine et al. 2010). The results of these and other studies mainly show that there actually seem to be positive cluster formation effects. However, the effect is very different at the respective height and depends on the sectors under consideration. The precise mechanism that may lead to the positive cluster formation effects remains unclear.

Cooke et al. (2007) use selected ICT cluster regions in the UK to show that companies have a higher innovation power in clusters than their counterparts outside of clusters. However, they also show that companies cooperating outside of clusters are more innovative than cluster members that do not cooperate. Cooperations therefore seem to be a decisive factor for innovation activities. It seems that not only own efforts for research and development (R&D) but also cooperation is an important strategy for innovation output in R&D projects.

Breschi/Lissoni (2001) are critical about the concept of local knowledge spillovers and their contribution to unintended externalities that mainly occur from geographic proximity of companies. Their criticism is targeted at studies showing the positive customer effect using a knowledge production function (Griliches 1979). The knowledge production function is based on the assumption that cluster formation happens more in sectors where tacit knowledge is very important. It is stated that tacit knowledge can only be

transferred by direct and repeated contact (Audretsch 1998). The knowledge production function differentiates between regional knowledge input (e.g. R&D expenditures) and extra-regional input. Differences in relative knowledge output (e.g. patent applications) are then interpreted as regional knowledge spillover (Breschi/Lissoni 2001). The actual development process of local knowledge spillovers remains a black box in the empiric analyses.

In spite of objections, e.g. by Breschi/Lissoni, the production knowledge function was used for most of the studies named to measure unintended knowledge spillovers. Breschi/Lissoni suspect that the actual effect of local knowledge spillovers is clearly overestimated. The patent trend increases in cluster regions to better protect against knowledge spillover (Kim/Marschke 2005). This is another reason why the patenting method that is also often used in studies is likely to lead to distorted results. Breschi and Lissoni argue that epistemic closeness is more important than physical limits. This means that technical and scientific information that have the character of tacit knowledge become codifyable knowledge, since there is a dedicated language in small groups of scientific and technical researchers that is only understood by them and develops by extended cooperation and joint experience (Lawson/Lorenz 1999). These things can be transmitted across distances without externals being able to understand these messages. Only fruitful cooperation and subsequent research agreements cause the cooperation partners to get closer in a spatial respect. Accordingly, physical proximity follows epistemic proximity rather than vice versa (Breschi/Lissoni 2001, p. 989). Furthermore, they argue that the role of tacit knowledge in general is overestimated, since this knowledge is often only interesting for other companies for founding of a dedicated company by the inventor if the lab or development conditions are identical. This applies for most high-tech sectors at least. This means that procurement of new knowledge is often connected to high investment costs. The risk for the company is high, since it does not know the real value of the new, non-codifyable knowledge for the company. The inventor will not easily surrender his knowledge, since this would mean dispensing with his "special" skill and reducing his "market value". Additionally, companies are able to create incentives, e.g. by issuing share options or other contractual instruments, to at least reduce an outflow of employees or knowledge.

In addition to the protective mechanism named, there are possible other reasons for increased patent activities in spatial proximity of research centers. Small and medium-sized businesses often do not have their own resources for development work, leading to a strong incentive for cooperation with local research organizations (Rodríguez-Pose/Refolo, 2003). This explains the increased patent output in the region but is not due to unintended local knowledge spillovers.

Malmberg/Power (2006) note that questioning of decision-makers in companies on the question of where the most important suppliers or customers for the companies are regarding knowledge and innovation showed that spatial proximity has no influence. High distances prevailed over spatial proximity of relationships (Angel/Engstrom 1995, Almeida/Kogut 1999, Waters/Smith 2006).

3.2.2 Knowledge Spillover Induced by Cooperation

Research and development activities can be organized differently by companies. Research and development may take place in the own company by subcontracting or deliveries, or by research cooperations with other companies or research facilities. Often, research and development work are implemented by a combination of these options. Entering into research and development cooperations is likely the most risky method of this, since transfer of specific knowledge to a potential competitor may be consciously risked. Nevertheless, the benefits from the resulting risk diversification in a cooperation may be more important. Risk diversification takes place by the shared development costs and higher chances of success of the innovation project. A cooperation is most likely entered into if the two companies offer complementary knowledge. Complementary knowledge means that combination of the knowledge stock of cooperation partners leads to new or improved knowledge innovation output (Sakakibara 2003). In particular in the ICT area, ICT goods or services are often complementary to a value in another sector. Since ICT is a cross-section technology, it is embedded in nearly every high-tech product. Often it forms a product's "core". Research cooperations between ICT companies and companies requiring ICT as an input component therefore are more logical than in most other sectors. Cooperations mainly take place between companies on different levels of the production chain, and less between companies horizontally connected (Schmitz 1999). Of course, cooperations will also lead to "unintended" knowledge spillover towards third parties. Even though third parties are not directly integrated into the research cooperation, they still profit via the channels already named – even more, since the cooperations tend to cause a stronger increase of the knowledge stock than would be the case without cooperation.

Malmberg and Power (2005) provide an interesting summary of empiric literature on creation of knowledge by companies in clusters. It becomes clear that empirical studies clearly indicate that companies in a cluster mainly profit from cooperation with partners outside the region. This means that local knowledge spillover plays a rather subordinated role. Kalasky/MacPherson (2003) show that cooperations of cluster companies with external companies correspond to a high performance of companies. Local connections are rather characterized by the exchange of sample goods and services than R&D knowledge (Brown, 2000). In contrast to what is suggested by the abundant theoretic literature, it seems that there is actually not much empiric evidence that cooperations in research and development within the clusters are more frequent than in regions not characterized by cluster formation (Angel 2002). A manageable number of studies shows that there may be a higher number of company cooperations, but that this will be limited to a small number of highly innovative companies (Lyons 2000) or small and medium-sized companies (Arndt/Sternberg 2000) or local companies (Gertler et al. 2000). Therefore it seems that the willingness to cooperate is influenced by sector and company-specific factors (Malmberg/Power 2005). Hendry et al.'s (2000) study on companies in the opto-electronics industry showed that national and international company relationships were much stronger than local ones. Kearns and Gorg (2002) show for Irish regions that the electronic industry does form clusters. However, the leading companies in the cluster

performed their research activities abroad and there were no or only low spillover effects on local companies. The studies by Simmie (2002) looking at innovative companies in South-East England and Mota/de Castro (2004) show that successful companies show a mix of local and extraneous cooperations or connections (Malberg/Power 2005, p.415). The heterogeneity of the empiric results regarding local knowledge spillover led to the motivation to consider cooperation conduct in the innovation process in more detail in this work.

3.2.3 Role of Cluster Management to Stimulate Knowledge Spillovers

The following analysis considers two periods each. The founding year of the cluster initiatives in the selected regions determines t_0 and t_1. The periods t_0 and t_1 describe the periods 10 years before and 10 after founding of the cluster initiative. Picking a period before and after the founding date seemed sensible for cooperation network analysis because the ICT cluster initiatives consider it one of their most important tasks to link (ICT) companies or (ICT) companies and research facilities among each other. The action range of the respective cluster initiatives is not determined precisely. However, the member lists of the networkers show that their member companies almost all have their headquarters in the respective NUTS-2 regions. The cluster organizations under consideration in the NUTS-2 regions are members of the network initiative *Kompetenznetze Deutschland,* initiated by the Federal Ministry of Economics and Technology. The initiative covers altogether nine topics, among them information and communications technology. Federal Government currently sponsors 15 networks in the field of information and communication technology. According to the Federal Ministry of Economics and Technology (BMWi 2010a), these I(C)T networks of competence across Germany aim to increase the interconnectedness between industry and research and to accord greater visibility to the advantages of Germany as an innovation-friendly location. While the initiative Networks of Competence offers specific assistance in cluster management to members, which are accepted according to determined criteria, its primary aim is to enhance the interconnectedness and external visibility of these networks for potential investors.[15]

Empirical studies that analyze the performance of cluster managements are still very scarce in the literature which is surprising as the establishing of such teams has become a very popular instrument in economics policy. Therefore, it can hardly be estimated how efficient the work of cluster organizations actually is. Lawton-Smith (2003) shows that cooperation networks between local actors should be an

[15] A minimum size of 10 actors is required and a corporate share of at least 50%. In addition, the involvement of a research institution must be ensured. Among the parties involved there should also be service providers, in particular financial services providers and basic and further training facilities. The BMWi also requires that the network focuses on a specific field of innovation and that it has specific unique features setting it apart. The organizational degree of the network is also of great significance. Next to "branding," this is the focus of the second pillar of sponsoring. The organization unit of the network or the cluster management will receive specific support, for example, for conducting workshops and industrial fairs. Further assistance is provided by the publication of trend reports, network-specific short studies, online newsletters, joint internet presentations, exchange and development of cooperation projects, internationalisation, i.e. the development of strategies for corresponding activities and the organization of group study visits (BMWi 2010b).

important foundation for cluster formation. In particular for young companies, cluster organizations should serve as contact points for finding suitable cooperation partners; whether cluster management actually successfully acts as intermediary here is hard to measure, since the quantity of success cannot be easily recorded. Often, soft indicators like provision of useful information and creation of formal and informal contacts are the most important part of the daily work of a cluster office. The following analysis also presents how member companies of the cluster organizations have integrated into the network within the period t_1, even if network analysis based on patents is only able to provide very limited results here, since the analysis method is not perfect. The following analysis focuses on the cooperation behavior of innovators (in ICT cluster regions).

3.3 Network Analysis – Cooperation Network of Patent Applicants in Selected German ICT Cluster Regions

3.3.1 Method Procedure

The following network analysis is based on the patent database PATSTAT offered by the European patent office. Since these are merely raw data, they were implemented using a database management system.[16] The advantages and disadvantages of patents as innovation indicators are often discussed in literature. A lot of innovations are never patented. A patent application does not always have a relevant market value. Additionally, the patent trend is different from sector to sector, and also depends on country-specific factors. Still, the interconnection between inventions and patents is very high. Patent data deliver detailed and standardized data for all business sectors and across a long period. Additionally, this analysis is dedicated to one country and one sector only, so that comparison is sensible at least between the regions under consideration. The analysis also focuses on networking patterns and less on innovation quality. The ICT sector in the NUTS-2 regions of Cologne and Karlsruhe is examined. Both regions have above-average patent applications in this sector as compared to the natural average. The cities of Karlsruhe and Aachen[17] are considered successful ICT cluster regions. The cooperation network was constructed as follows:

Every patent has the address of the inventor or inventors. Furthermore, the address of the applicants is written on the respective patent. The applicants are involved in the innovation process and are therefore described as innovators. The inventors are natural persons while the applicant is often a company for which the inventor works.

[16] For the precise implementation process, see Mahmutovic (2011). Together with Oliver Emons, Zafir Mahmutovic implemented the patent database EIIW-Netpat in the scope of the research project *EU structural change, regional innovation dynamics and cluster formation options in the knowledge societies* for the European Institute for International Economic Relationships (EIIW) at the Bergische University of Wuppertal.

[17] Aachen is located in the NUTS-2 region of Cologne.

The first criterion is that only ICT patents are considered on which at least one inventor has his permanent place of residence within the region under consideration. It is assumed that this is also the place of knowledge production. The OECD REGPAT database is used for assignment of the addresses of applicant and inventor to the NUTS regions. The second criterion is that at least two applicants are stated on the patent so that a cooperation can be assumed. This means that an inventor from the respective region under consideration worked for innovators A and B, who then registered a patent.

The networks developed are so-called total networks, showing the type of relationship between the actors of a specified examined group of actors to every other actor of this group, or the lack thereof. For personal networks, in contrast, the relationship types between the different actors and a specific examined group of other actors are examined – no matter if they are part of the examined group or not. This means that there is no self-contained group of actors for personal networks, which is, however, the case in the following networks (Emons 2011, p.333). In rare cases, a applicant may occur twice in a network. This is the case if two different addresses are indicated on two different patents. However in the case of a firm as an applicant the address on the patent is usually equal to the address of the firm´s headquarter in the country. Generally, cooperation networks are presented with knowledge at least partially generated in the cluster region under consideration. They are differentiated by the applicant's address indicated on the patent. Networks were drawn up in which the applicants are headquartered within the region, as well as networks where at least one applicant is headquartered outside of the region. The third option was construction of networks in which all applicants have their address outside of the NUTS-2 regions under consideration according to the patent letter (see networks in the appendix). Now I want to show how external applicants "tap" the knowledge regions to increase their knowledge basis or how the cooperations develop interregionally over time.

The IPC classes that define the ICT sector are listed in the appendix. It is essentially based on OECD classification for ICT. All isolated applicants were removed from the networks. Differing node sizes (applicants) and connection thicknesses between the notes to display intensity of cooperations was waived for the benefit of a clear structure. This is made clear by the network analysis measures for every network and therefore the respective position of the innovator in the network. The placement of nodes that represent the applicants does not correspond to any spatial order that represents the geographic position or distance between the companies.

3.3.2 Network Measures

The analysis lists three networking measures (the following explanations are in part based on Emons 2011, p. 337 et seqq.).

The *density* of a network offers information on the ratio of actual relationships as compared to the possible relationships in a network, it is a measure for how closely a group is linked. If g is the number of actors, the number of possible relationships (indegree and outdegree) is:

(1) g*(g-1)

However, this does not consider the actual relationships a. The density, i.e. the number of actual relationships in the respective network, results from:

(2) a/g*(g-1)

Density is a simple measure and therefore only suitable for comparison between identically sized networks. *Centrality* helps making statements on the inner structure of the network. There is a difference between the *degree centrality* and the so-called *betweenness centrality* (Freeman 1978). Degree centrality makes a statement on the position of a single actor, in this case the innovators, in the network. It is a value describing the number of relationships that every actor in a network has to the other actor and is formally phrased as follows:

(3a) $C_D(i) = d_i/(g-1)$

With D(i) being the number of all adjacent items of the applicant i. Therefore, not the overall network properties, but the properties of the individual actors are taken under consideration. This represents the number of the incoming and outgoing relationships of an actor. The centrality degree of the entire network can be calculated as well:

(3b) $C_D = \sum_{i=1}^{g} (\max(C_i) - C_i) / g - 2$

In contrast to density, degree centrality can be used for differently sized networks. For comparability's sake, we calculate the *average degree centrality*, which provides information on how many relationships every actor maintains on average. Furthermore, the so-called *betweenness centrality* (according to Freeman, 1978) is calculated as follows:

(4a) $C_B(i) = \sum_{j \neq i \neq k} \frac{g_{jk}(i)}{g_{jk}}$

g_{jk} indicates the number of points that connect applicants j and k along the shortest path. $g_{jk}(i)$ designates the number of such paths that also include applicant i. 1 means a star shape, 0 indicates that all actors have the same degree. Betweenness centrality indicates how centrally an actor is located regarding information exchange within a network. A applicant with a high betweenness centrality holds an important role when exchanging information within the network. The network betweenness centrality results from

(4b) $C_B = \frac{2\sum_{i=1}^{g} [\max(C_B(n)) - C_B(i)]}{[g-1)^2 (g-2)}$,

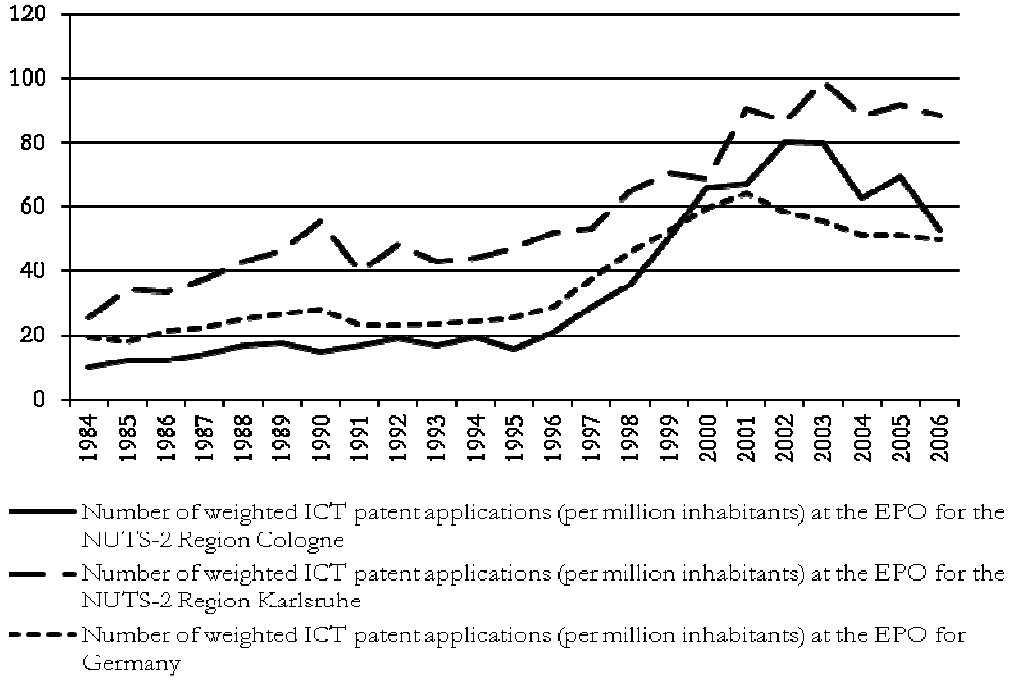
where $\max(C_B(n))$ is the highest value of betweenness centrality of a node and g is the number of nodes in the network (Wasserman/Faust 1994).

3.3.3 Descriptive Statistics

NUTS-2 region Cologne:	NUTS-2-region Karlsruhe:
Seize: 7364.61 Sqkm	Seize: 6919.09 Sqkm
No. of Inhabitants	No. of Inhabitants
(on average from 1984-2007): 4.30 Mio.	(on average from 1984-2007): 2.74 Mio.
Name of the Cluster Initiative:	Name of the Cluster:
REGINA e.V. (**REG**ionaler **IN**dustrieclub	Initiative : CyberForum
Informatik **A**achen)	
Start of the Initiative: 1993	Start of the Initiative: 1997
Domicile of the cluster office: Aachen	Domicile of the cluster office: Karlsruhe
No. of cluster member in 2011: 110	No. of cluster members in 2011: 930

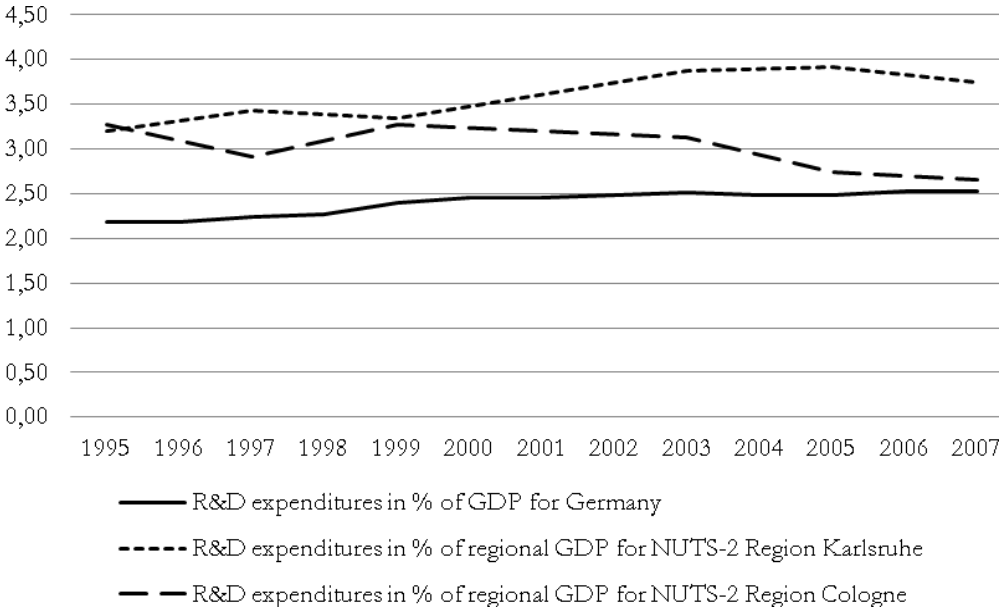
The following figure shows the patent applications in relation to the number of residents. The NUTS-2 region of Karlsruhe is clearly above the national average in the period under consideration while the region of Cologne only exceeds the national average at the end of the 1990s after being below it previously. The figure 3.2 shows the R&D expenses for the region of Cologne drop over time and adjust to the national average. The region of Karlsruhe is clearly above the German overall average and even manages to clearly increase the distance over time.

Figure 3.1 Number of Weighted ICT Patent Applications (for the Period 1984-2006)



Source: PATSTAT (Own Calculations and Illustration)[18]

Figure 3.2 R&D Expenditures in % of (Regional) GDP[19] (for the Period 1995-2007)



Source: Eurostat/Own Illustration

[18] Definition for ICT patents see appendix
[19] No data available for the time before 1995 concerning the NUTS-2 regions

3.3.4 Results

Table 3.1 Cooperation Network Measures of NUTS-2 Region Cologne

NUTS-2 region Cologne for the period of	**1984-1993**	**1994-2003**
Number of all weighted ICT patent applications:	643	1993
Number of applicants > 1 per patent (Nodes)	96	225
Ratio of applicants > 1 per patent (cooperations)	14.93%	11.28%
Number of applicants that are also members of the cluster initiative		3
Network Density	0.025	0.0116
Network Degree centrality C_D	7.04%	10.09%
Network Betweenness Centrality C_B	0.42%	1.47%
Average Ties per Actor	2.375	2.596
Inclusion of Research Institutes	Yes	Yes

Most Central Applicants/C_D(i) in %
(Degree-Centrality)

1984-1993
n.v. Vaillant s.a./9.474
VAILLANT p.A.R.L/9.474
Vaillant GmbH/9.474
Joh. Vaillant GmbH u. Co./9.474
VAILLANT Ges.m.b.H/9. 474
Vaillant Ltd./9.474
SCHONEWELLE B.V./8.421
COFRABEL N.V. /8.421
Vaillant-Schonewelle B.V./8.421
Vaillant B.V./6.316
FORD-WERKE AKTIENGESELL-SCHAFT/5.263
Koninklijke Philips Electronics N.V./5.263
SIEMENS AKTIENGESELLSCHAFT/4.211
Philips Corporate Intellectual Prop. GmbH/4.211

1994-2003
Philips Intellectual Property & Standards GmbH/11.161
Koninklijke Philips Electronics N.V./10.714
ROBERT BOSCH GMBH/6.696
NXP B.V./6.250
Daimler AG/6.250
Volkswagen AG/5.804
BMW AG/5.357
Decomsys - Dependable Computer Systems, Hardware and Software Entwicklung GmbH/5.357
GENERAL MOTORS CORPORATION/5.357
Freescale Semiconductor, Inc./5.357
Bayerische Motoren Werke Aktiengesellschaft/5.357
MOTOROLA, INC./5.357
Forschungszentrum Jülich GmbH/4.018
Bayer MaterialScience AG/3.125

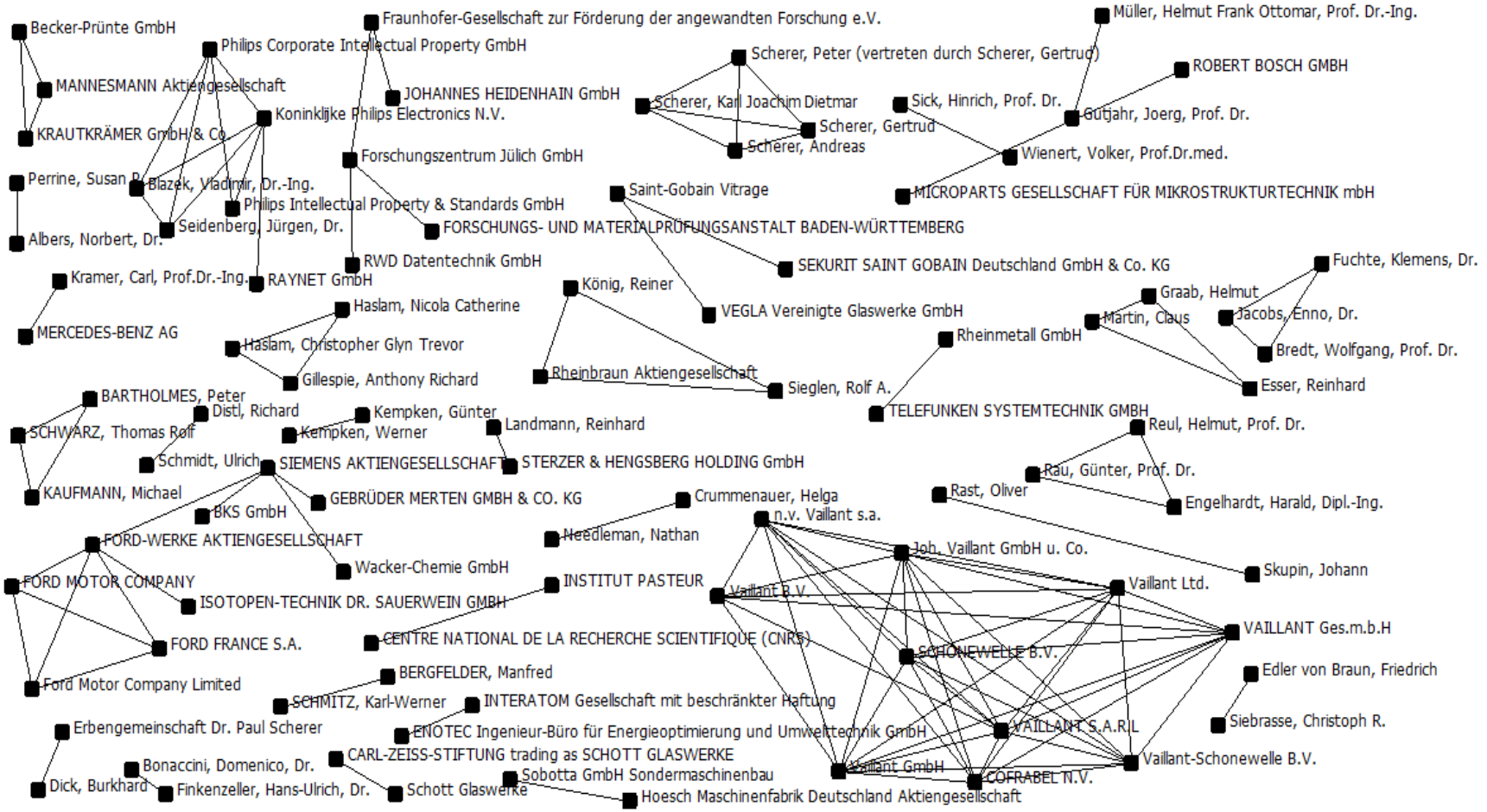
Most Central Applicants/C_B(i) in %
(Betweenness-Centrality)

1984-1993
FORD-WERKE AKTIENGESELL-SCHAFT/0.426 Daimler AG/1.497
SIEMENS AKTIENGESELLSCHAFT/0.403
Koninklijke Philips Electronics N.V./0.112
Forschungszentrum Jülich GmbH/0.112
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V./0.067
Philips Corporate Intellectual Property GmbH/0.022
Saint-Gobain Vitrage/0.022
n.v. Vaillant s.a./0.011
Vaillant GmbH/0.011
Vaillant Ltd./0.011
VAILLANT G.m.b.H/0.011
Joh. Vaillant GmbH u. Co./0.011
VAILLANT p.A.R.L/0.011

1994-2003
Deutsche Telekom AG/1.413
Philips Intellectual Property & Standards GmbH/1.217
Koninklijke Philips Electronics N.V./ 1.041
Forschungszentrum Jülich GmbH/0.677
Fraunhofer-Gesellschaft zur Förderung/ der angewandten Forschung e.V./0.516
T-Mobile Germany GmbH/0.348
AUDI AG/0.344
ROBERT BOSCH GMBH/0.302
SIEMENS AKTIENGESELLSCHAFT/0.176
Volkswagen AG/0.176
Bayer MaterialScience AG/0.157
NXP B.V/0.126

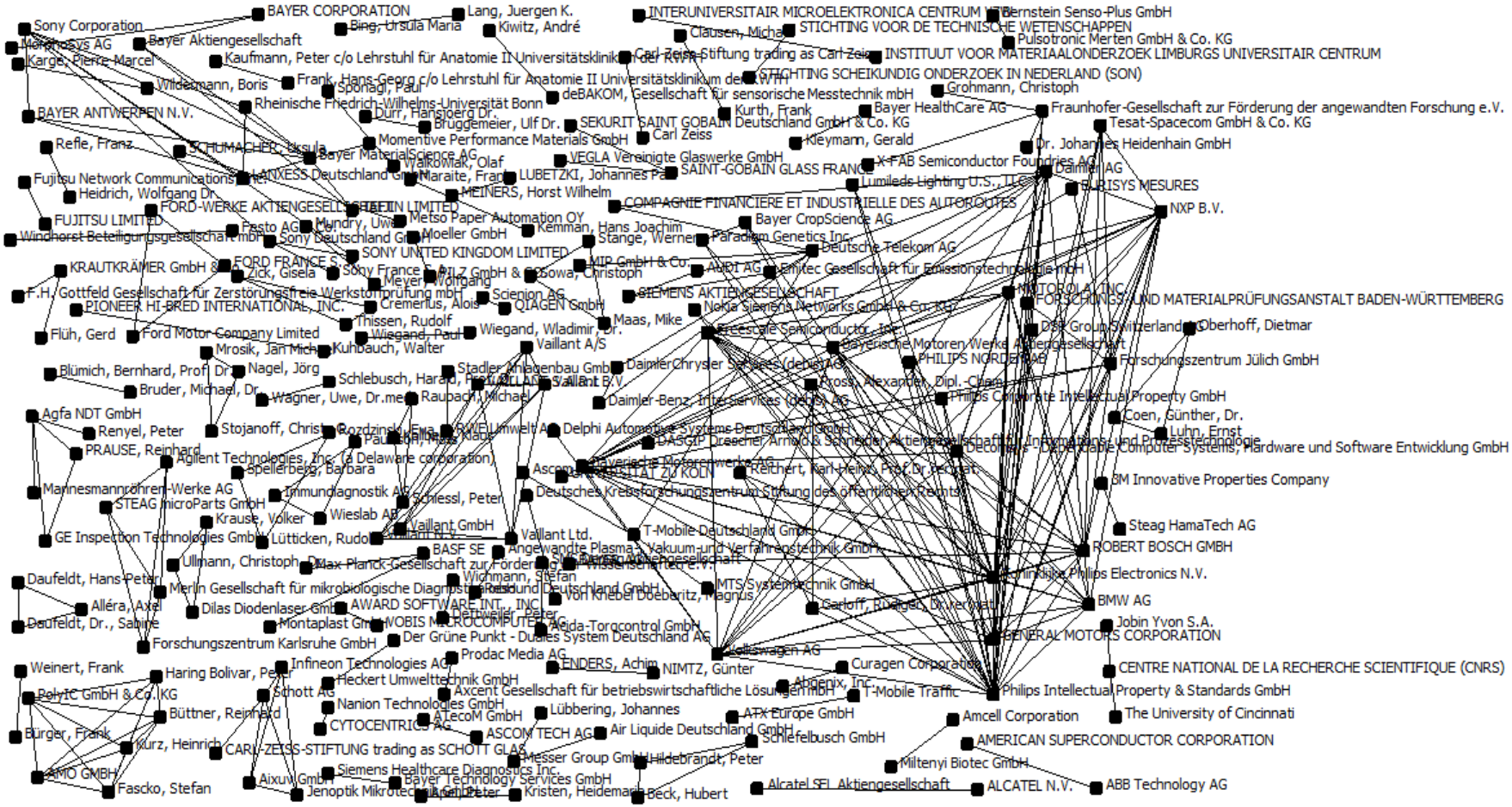
Source: Own Calculations

Figure 3.3 Cooperation Network for the NUTS-2 Region of Cologne for the Period of 1984-1993 (t_0)



Source: Own Illustration

Figure 3.4 Cooperation Network for the NUTS-Region Cologne for the Period of 1994-2003 (t_1)



Source: Own Illustration

Table 3.2 Cooperation Network Measures of NUTS-2 Region Karlsruhe

NUTS-2 region Karlsruhe for the period of	**1988-1997**	**1998-2007**
Number of all weighted ICT patent applications:	1273	2103
Number of applicants > 1 per patent (Nodes)	157	211
Ratio of applicants > 1 per patent (cooperations)	12.33%	10,03%
Number of applicants that are also members of the cluster initiative		5
Network Density	0.0171	0.0111
Network Degree Centrality C_D	4.76%	5.60%
Network Betweenness Centrality C_B	0.82%	1.81%
Average Ties per Actor	2.675	2.341
Inclusion of Research Institutes	Yes	Yes

Most Central Applicants/$C_D(i)$ in %
(Degree-Centrality)%

1988-1997
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V./6.410
KERNFORSCHUNGSZENTRUM KARLSRUHE GMBH/6.410
Forschungszentrum Karlsruhe GmbH/5.769
SEL Aktiengesellschaft/5.769
Daimler-Benz AG/4.487
SIEMENS AKTIENGESELLSCHAFT/4.487
Sauer, Markus/4.487
Koninklijke Philips Electronics N.V./4.487
Köllner, Malte/4.487
Schulz, Andreas/4.487
KRONE Aktiengesellschaft/4.487
Seidel, Claus/4.487
ANT Nachrichtentechnik GmbH/4.487

1998-2007
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V./6.667
Volkswagen AG/6.190
Daimler AG/5.714
ROBERT BOSCH GMBH/5.714
Forschungszentrum Karlsruhe GmbH/5.238
BASF AG/5.238
Bayerische Motoren Werke Aktiengesellschaft/4.762
Deutsches Krebsforschungszentrum/4.762
MOTOROLA, INC./4.286
Freescale Semiconductor, Inc./4.286
Koninklijke Philips Electronics N.V./4.286
Philips Intellectual Property & Standards GmbH/4.286
GENERAL MOTORS CORPORATION/4.286
BMW AG/ 4.286

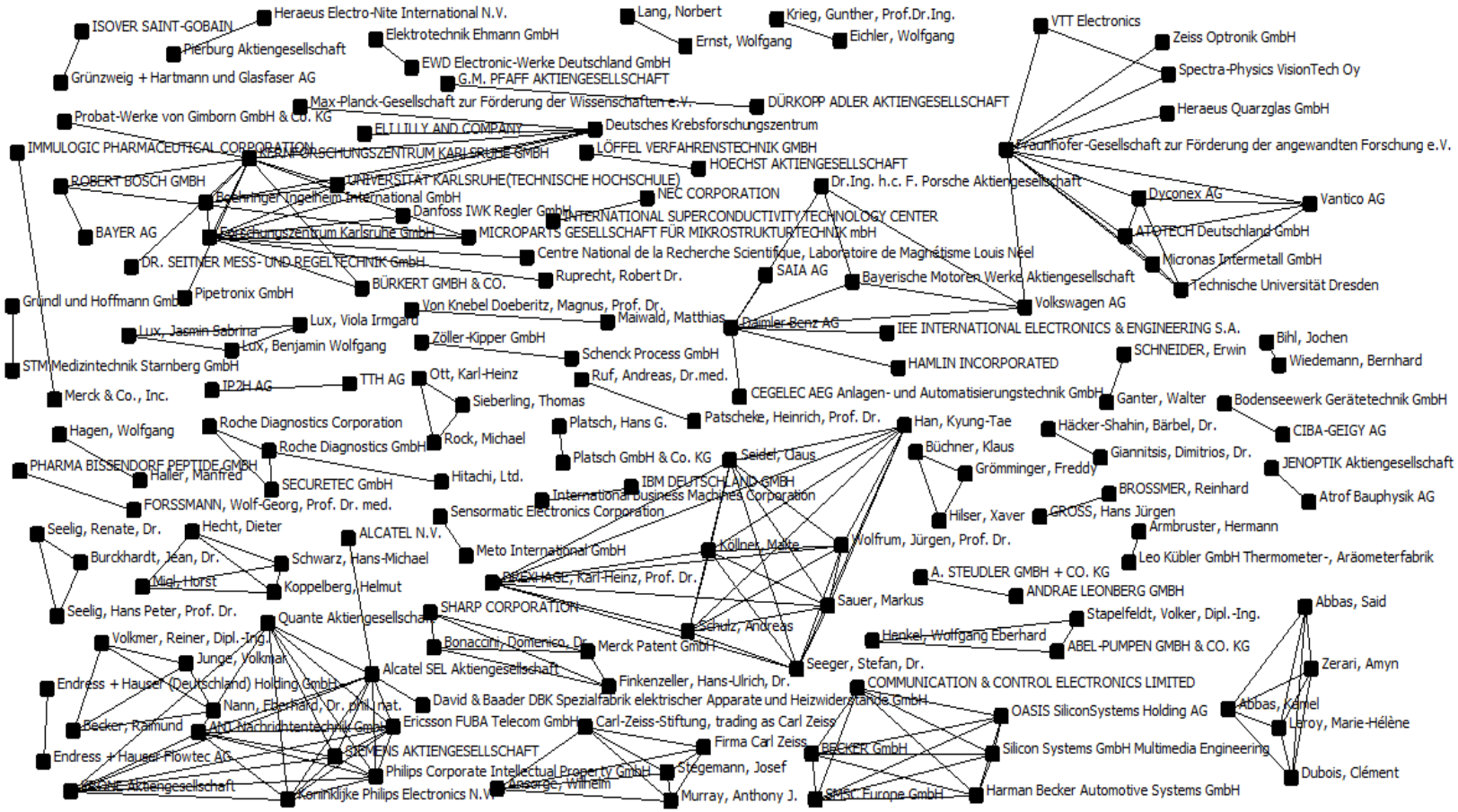
Most Central Applicants/$C_B(i)$ in %
(Betweenness-Centrality)

1988-1997
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V./0.835
Volkswagen AG/0.579
KERNFORSCHUNGSZENTRUM KARLSRUHE GMBH/0.525
Daimler-Benz AG/0.480
Forschungszentrum Karlsruhe GmbH/0.393
Deutsches Krebsforschungszentrum/0.240
ROBERT BOSCH GMBH/0.124
Alcatel SEL Aktiengesellschaft/0.124
MICROPARTS GESELLSCHAFT FÜR MIKROSTRUKTURTECHNIK mbH/0.033
Roche Diagnostics GmbH/0.017

1998-2007
Deutsches Krebsforschungszentrum/1.854
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V./1.720
Forschungszentrum Karlsruhe GmbH/1.400
ROBERT BOSCH GMBH/1.394
BASF AG/1.390
Europäisches Laboratorium für Molekularbiologie/1.094
Volkswagen AG/0.581
Daimler AG/0.437
Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V./0.430
Roche Diagniostics GMBH/0.319
Lucent Technologies Inc./0.173
Boehringer Ingelheim International GmbH/0.173

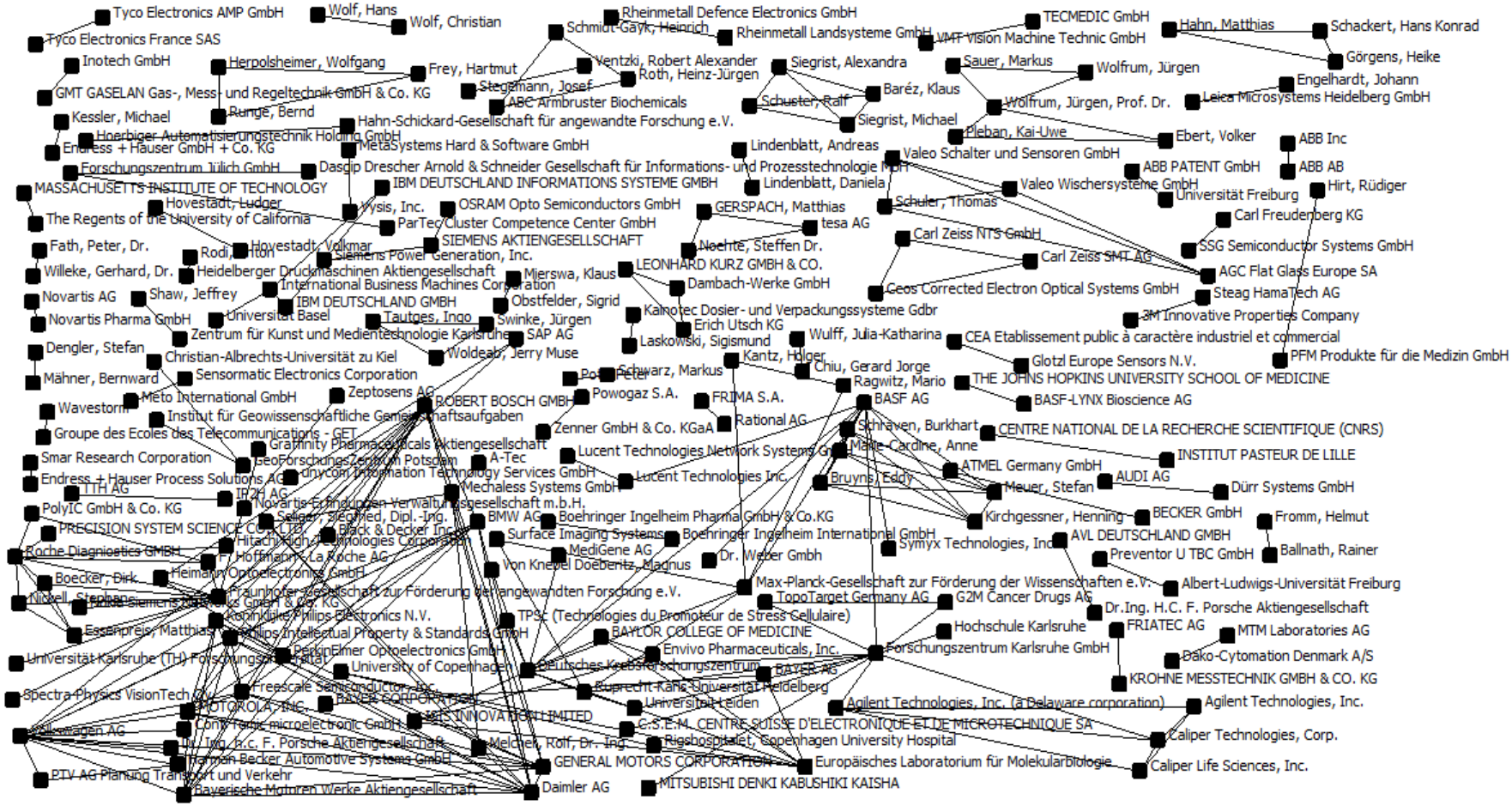
Source: Own Calculations

Figure 3.5 Cooperation Network for the NUTS-2 Region of Karlsruhe for the Period of 1988-1997 (t_0)



Source: Own Illustration

Figure 3.6 Cooperation Network for the NUTS-2 Region of Karlsruhe for the Period of 1998-2007 (t_1)



Source: Own Illustration

3.3.4 Results for the NUTS-2 Region Cologne

The number of cooperations has clearly increased from 643 to 1993 as compared to the previous period, showing very dynamic development. This becomes visually clear in the cooperation network figure. The network measures confirm this first impression. The network degree centrality C_D and network betweenness centrality C_B increase as compared to the previous period (t_0). The average number of connections between the applicants has also increased from 2,375 to 2,596. The Vaillant Group, in t_0 still the most central applicant in the cooperation network, lost its central position. The dominance of Vaillant across several companies in the period t_0 is distributed to several companies like Philips, Bosch, NXP, Daimler, Volkswagen and BMW in period t_1. Similar results are shown in betweenness centrality. Again, further diversification has resulted. Betweenness centrality values for the most important innovators have clearly increased and the order has changed. Large groups from the automotive sector are important – among them Deutsche Telekom AG and Siemens. The research institutes Forschungszentrum Jülich and Fraunhofer were able to maintain their positions as knowledge intermediaries (in the sense of betweenness centrality) as compared to period t_0. To achieve this, they clearly increased their centrality values from 0.112 and 0.067 respectively to 0.677 and 0.516 respectively. It is noticeable that research holds an important position in ICT research cooperations nearly at all times and in every network. Looking at the partial networks for Cologne in a more differentiated analysis (see networks in the appendix), i.e. by the address where the applicants are headquartered, shows that in particular companies headquartered outside of Cologne act as intermediaries of cooperations or knowledge. Betweenness centrality of the entire network and individual leading innovators increases most clearly here. The betweenness centrality of the network for applicants headquartered in Cologne increased from 0% to 0.17%, staying low. It is clear that almost all applicants in this network are private persons, for both periods t_0 and t_1.[20]

In general, it can be said that the importance, i.e. centrality, has moved towards large companies and research facilities headquartered outside of the NUTS-2 region of Cologne over time. The number of companies from outside the region nearly tripled. This also applies for cooperations where at least one cooperation partner comes from the region, while cooperating innovators completely outside of the NUTS-2 region of Cologne only increased from 24 to 36 in absolute figures. This is also represented in the example of the Forschungszentrum Jülich, which is headquartered in the region of Cologne and is often represented as an important player in the different networks. Only in the network that considers only companies headquartered in Cologne it is merely subordinated in importance in t_1. Three companies that are members of the Clusterinitiative REGINA e.V. are part of the overall network in t_0.

[20] It must be noted that natural persons with a professor's title very often can be assigned to research institutions. Until 2002, German patent law permitted university professors to register a patent in their name rather than the university's name.

3.3.5 Results for the NUTS-2 Region Karlsruhe

Similar as in the region of Cologne, the number of ICT research cooperations clearly increased from 1273 to 2103. Even if the relative increase is lower, observe that the initial level is much higher in the region of Karlsruhe. Development is in parallel to the region of Cologne. Again, the centrality measures for the cooperation network have increased over time. While network degree centrality increases slightly, the value for betweenness centrality clearly increased from 0.82% to 1.81%. The importance of knowledge intermediaries in the scope of research cooperations has therefore clearly increased. With a view to the overall network, but also the differentiated networks (see appendix) for the region of Karlsruhe it becomes clear that the research institutions always hold a central position. Many research institutes like Fraunhofer, Forschungszentrum Karlsruhe, Deutsches Krebsforschungszentrum, Kernforschungszentrum Karlsruhe, Max-Planck-Gesellschaft, etc. are involved in periods t_0 and t_1. A high ratio of research institutes comes from the region or has at least an important site there. Expansion of the cooperations is obviously due to the many cooperations of research companies. They seem to cooperate less with each other, as is shown by the innovator network only headquartered in Karlsruhe, but rather with companies from the outside. Research institutions are important in the Cologne network, and extraordinarily so in their function as knowledge intermediaries or innovators here.

The knowledge region of Karlsruhe is not tapped by cooperating companies, headquartered only outside of it as in the case of the region of Cologne. The number of cooperations in which all cooperation partners are headquartered outside of Karlsruhe increased only from 69 to 91 joint patent applications. It is notable that the most important companies from the outside include Bosch Volkswagen, Daimler, BMW and Philips, the same ones as in the region of Cologne. Five companies are members of the regional cluster initiative CyberForum.

3.4 Summary of Results and Conclusions

A network analysis was performed in the German ICT cluster regions of Cologne and Karlsruhe, on the NUTS-2 level. It was targeted at examining the cooperation conduct of innovators. The data basis was the patent database PATSTAT. The raw data provided was prepared so that all ICT patents with at least one inventor resident in one of the regions were filtered out. In a second step, the patents from this data volume with more than one innovator (applicant) were analyzed. It may be assumed that the patent applicants know each other and that they cooperate within a joint research project. Cooperation networks were generated for networks or network measures and their development was illustrated and analyzed for two periods of 10 years each for either region. The objective was showing how cooperation behavior dynamics develop in an economic sector in which successful cluster formation has taken place at the same time. Who were the important actors in this process, and what was the role of inter-regional cooperations?

How are external innovators integrated into the network? Did the regions go through parallel development?

The results show that the cooperation behavior in the cluster process also developed dynamically. In both regions, the network expanded and continued to diversify, while also enhancing its structures. This becomes clear by the analytic measures, as well as the graphic network mappings. The overall networks in the two regions show that cooperation intensity has continued to increase, at concurrent increase of the number of cooperating innovators. Only Karlsruhe showed some small relative reduction of the average number of cooperation relationships. In both regions there are several important innovator cooperations regarding number and intensity. There is no danger of cooperation networks breaking apart due to loss of one innovator. The clear increase of betweennness centrality in both networks is notable. Knowledge intermediation has clearly increased. Knowledge transfer between innovators with a third party integrated has clearly increased.

It is not surprising that the most important innovators are large companies. In particular multinational ICT companies and automotive groups are central actors in the cooperation networks. The differences between the regions become clear here as well. While the overall networks develop dynamically in parallel over time, drivers for cooperation conduct in the region of Cologne are cooperations with external companies. They often tap the knowledge region. This means that they cooperate with inventors from the region while being headquartered outside of it. Additionally, there is a strong increase of cooperations between regional companies and external companies in Cologne. The interregional cooperations developed much less dynamically in both regions.

In the region of Karlsruhe, many research institutions are involved in cooperations or serving as knowledge intermediaries, in addition to large multi-national groups that are, interestingly, often the same ones as in the region of Cologne . This is the case of the region of Cologne as well, but Karlsruhe often has more than five different research institutions as most important players in the network and therefore is extraordinarily strongly placed here. On the other hand, cooperating external companies do not play the important role for network expansion that they do in the NUTS-region of Cologne. Network expansion in the region of Cologne therefore was driven more strongly by companies from the outside, and in the region of Karlsruhe by research cooperations with at least one research institute from the region as innovator.

Three and five companies respectively among the cooperating investors in networks are members of the cluster initiative. To assess the role of cluster organizations, supplementary quality analysis is indispensable. Measuring the networking success in the innovation process by patent analysis without any further information on the members only would be insufficient and would not meet the requirements of evaluation of cluster organization activities. However, supplementary qualitative analysis would be highly interesting to look more closely at the cluster initiative's role.

This analysis indicates that individual cluster promotion is required and that a strategy customized for the region in question should be pursued. While the region of Cologne has developed from a below-average to an above-average ICT knowledge region at least regarding ICT patent applications by, e.g., increased cooperation between regional companies and external companies, integration of the research institutes as knowledge intermediaries or cooperation partners in R&D was likely a decisive factor for further development of Karlsruhe as an ICT site. In any case, cooperations and successful cluster formation seem to coincide. Networking appears to be relevant. If these networking activities are promoted by third parties (e.g. a cluster organization), external companies should in any case be considered as potentially matching partners in the innovation process for regional companies.

Of course, this thesis is a rather descriptive analysis that provides an additional component for the German ICT sector created by network analysis, an analysis instrument not very widely used in business sciences yet, in the light of the many cluster analyses today. In addition to the disadvantages of patent analysis already named, this method cannot easily empirically analyze causative interrelations. Additionally, there are the usual limitations resulting from the administrative and therefore artificial thresholds, such as the NUTS-2 level for a cluster analysis. However, it appears obvious that successful regional ICT cluster formation by cooperations with external companies and integration of research institutions are important factors for success. It remains unclear, in how far local knowledge spillovers in the form of cooperations play a role and whether other factors like lower transaction costs or a specialized local labor market would offer better explanations for a spatial agglomeration of companies from the same sector. Interregional cooperations develop much less dynamically in both regions, in any case.

4. Does the Financial System Affect Early Stage Venture Capital Investments?

JEL: G24

Keywords: Early Stage Venture Capital, Risk Capital, Financial System, Financing Innovations

Abstract: Improving access to finance is one of the key factors for increasing the number of innovative business start-ups with high growth potential. In this context, venture capitalists (VCs) have successfully dealt with the problems of financing innovative projects.

The existing literature suggests that VC investments are strongly negatively affected by the characteristics of a bank-centered financial system and this negative influence could be one reason for different VC investment levels across the OECD countries.

This paper is the first analysis that includes the relative size of the banking sector to produce evidence regarding whether, as is suggested in the predominant theoretical financial literature, the negative impact of a more bank-based financial system can withstand the empirical evidence The fundamental argument supplied by Black and Gilson argues that banks are not able to duplicate the implicit contract regarding future control as a market-based system can. Additionally, a more market-based system provides more lucrative exits via IPOs. Whereas markets are complements for VC, banks are to some extend substitutes. The panel analysis conducted for 16 OECD countries supports this view.

4.1 Introduction

Improving access to finance is one of the key factors for increasing the number of innovative business start-ups with high growth potential. Thus, the financial environment plays a crucial role in promoting innovation. In the process of financing innovative firms, a notably large information asymmetry between the capital seeking innovator and the capital provider regarding the likelihood of success in realizing a new idea as a marketable product is possible; moral hazard is a significant obstacle. Therefore, the marketplace for financing the development of innovative ideas is similar to the "lemon" market modeled by Akerlof (Hall 2002). Therefore, it is difficult for outside investors to make reliable assessments of the demand for products/services in highly immature markets. The threat of accelerated redundancy in rapidly changing technology-based sectors is strong. Investments frequently include research and development (R&D) costs and large expenditures in the marketing phases. Even if the product is promising, the entrepreneurial recipients of the investors' funds frequently lack the necessary managerial experience and, therefore, the ability to exploit the profits from the new technological innovation (Storey 1995, Murray 1998). Empirical studies provide results demonstrating that R&D expenditures will be determined by the available cash flow (e.g., Hall 1992, Himmelberg and Petersen 1994, Harhoff 1998). However, the effect differs between countries (Mulkay et al. 2001). Empirically, results focusing on new firms show that they are more financially constrained because they cannot use profits accumulated earlier to finance their R&D projects

(Moore 1994, Petersen and Rajan 1995; Berger and Udell 2002, Carpenter and Petersen 2002, Czarnitzki 2006). Moreover, older firms could benefit from their established relationships with banks and, therefore, reduce problems of asymmetric information.

In this context, venture capitalists (VCs) have been well-established in the US during the last four decades and have successfully dealt with the problems of financing innovative projects. VCs typically serve as intermediaries for risk capital from institutional investors, such as pension funds, insurance companies, banks, and funds of funds. VCs are typically specialized in one or a few specific sectors to screen the market for promising companies with extraordinarily high growth opportunities. Venture capital (VC) is subdivided with respect to different stages. Early-stage VC is VC that is provided at the beginning of the business cycle (the so-called seed (or pre-seed) and start-up phases), which is critical, as no final product frequently exists. This investment stage is obviously risky. The costly and time-consuming period of due diligence in seed and early-stage deals often makes these investments less profitable compared to later-stage VC investment deals that provide more attractive risk-return profiles (European Commission 2005). The less risky, later-stage VC investments that encompass expansion and replacement investments could be more attractive for VCs. Therefore, a financing gap exists, particularly in the start-up phase (European Commission 2006).

The success of the VCs depends not only on their experience and ability to find adequate enterprises but also on the in the economic environment of the country in which VCs invest. Jeng and Wells (2000), Romain and Van Pottelsberghe (2004a) and Schertler (2004, 2007) have examined which factors drive VC investments in OECD countries from a macroeconomic perspective, as the amount of VC invested (e.g., in Europe) differs enormously. While in Greece, early-stage VC investment was 0.001% of the gross domestic product (GDP), in the United Kingdom the amount was 0.218%.

The studies mentioned above do not include the role of the banking sector in explaining early-stage VC investments, but the existing VC literature suggests that VC investments are strongly negatively affected by the characteristics of a bank-centered financial system and this negative influence could be one reason for different VC investment levels. If so, one can argue that innovative start-ups in a more bank-based economy have disadvantages in raising capital compared to young entrepreneurs in market-based economies. However, this finding means that with a more bank-based financial system, the existing macroeconomic innovation potential of the whole economy is not optimally explored. As other studies have already shown, a vibrant stock market is an important positive factor to stimulate VC investments; this study demonstrates that the relative size of the banking system has a significant negative impact on early-stage VC investments. The following section presents, in a nutshell, some arguments for why VCs are successful in establishing young firms. Section three discusses how market-based and bank-based financial systems affect VC investments. This section arrives at the hypotheses that a market-based system fosters early-stage VC investment and that a bank-based system prevents early-stage VC investment. The panel analysis conducted for 16 OECD countries in section four supports this view. Section five closes with some concluding remarks.

4.2 The Positive Economic Impact of Venture Capital

Frequently, VCs support the nascent entrepreneur not only with capital but also with advice and management expertise (Amit et al. 1998). VCs may sit on boards of directors to provide valuable governance and advisory support (Romain and Pottesberghe 2004a). If performance objectives are not met, the VCs are normally in a powerful, contractually guaranteed position to reconsider the strategic objectives and the members of the management team. Hellman and Puri (2000) show that VCs replace the founder twice as often as non VC-backed firms. The capital seeker has to grant additional rights to the VCs. The VC usually receives convertible preferred stock. Like a debt contract, preferred stock requires the firm to make fixed payments to the shareholders, while the payments promised to preferred stockholders must be made before any common shareholder gets dividend payments and implemented such that the entrepreneur is not paying himself high dividends (Berlin 1998). When a VC holds shares in a young firm, which means that the shares are not marketable to other investors, the venture capital investor avoids the free-rider problem. The investor is able to earn profits from its monitoring activities and relieve the information costs of moral hazard (Hubbard 2008, p.240). An additional aspect is that the VCs do not make an investment all at once. Instead, capital is provided in stages, and the entrepreneur only receives enough funding to reach the next stage (Davila et al. 2003).

VC companies are typically specialized in one or a few industry sectors. This specialization deepens technical knowledge and enables the VCs to select risky investments more efficiently. Fenn et al. (1995) estimate that only one percent of all firms seeking capital obtain financing through venture capital. Gebhardt and Schmidt (2001) also conclude that VC promotes less than five percent of all potential projects. Actual data from national, European and US Private Equity and VC Associations confirm this ratio. As a result of such a stringent selection process, Kortum and Lerner (2000) find that increases in VC activity are associated with significant increases in patent rates in the US. Moreover, they show that VC investments are three times more effective in generating industrial innovation than are R&D expenditures. A similar study for Europe by Popov and Rosenboom (2009) finds that the impact of €1 of private equity[21] relative to €1 of industrial R&D expenditures is 2.6 times more effective in terms of producing innovations as measured by patents.

Hellmann and Puri (2000) find that a start-up company financed by VCs needs less time to bring a product to the market.[22] Empirical evidence shows that VC-backed firms grow much faster, at least in the beginning, than do non-VC-backed firms (Engel 2002, Engel/Keilbach 2007). Berger/Udell (1998) and

[21] Beside VC, private equity also includes management buyins (MBI) and management buyouts (MBO). A management buyout (MBO) is a form of acquisition where a company's existing managers acquire an all or a large part of the company. An MBI occurs when a manager or a management team from outside the company raises the necessary finance, buys it, and becomes the company's new management. In general, MBIs and MBOs are financed by debt and occur in less risky, and therefore often less innovative, industry sectors, which are characterized by relatively stable cash flows.

[22] However, their survey contains 149 recently-formed firms in the Silicon Valley, and this local concentration should be taken into account before interpreting their results.

Gompers/Lerner (1999) emphasize that venture-backed firms outperform non-venture-backed firms because of their willingness to conduct pre-investment screening and their special ability to monitor and assess value added. Belke et al. (2004) reveal that VC spurs employment growth through the efficient screening of innovative start-ups.

In the existing literature, to explain the heterogeneity between countries with respect to (early-stage) VC investment volume, a distinction is made between the innovation capacities (Engel/Keilbach 2007) and regulatory frameworks with particular with regard to contractual relationships and hence corporate governance (Hege et al. 2009, Hellmann 1998) but also for pension investment regulation (Gompers/Lerner, 1998), public support measures (Da Rin et al. 2006), institutions (Li/Zhara 2011, Cherif/Gazdar 2009, Bruton et al. 2005) and cultural aspects (Li/Zhara 2011). There is scant empirical evidence regarding the role the financial system has in explaining the different amounts of early-stage VC investments within the OECD countries. Black and Gilson (1998) are among the few who provide a remarkable contribution toward a theoretical basis for why VC in a bank-centered system provides less incentive for entrepreneurs to ask for VC and why less VC is provided on the supply side. The next section derives a hypothesis for why banks are, to some extent, substitutes for VCs and markets are complements for VCs. The following analysis adds a new puzzle piece to the existing empirical VC literature to augment the understanding of why early-stage VC investments in OECD countries differ enormously.

4.3 Venture Capital Investments and the Financial System

The traditional perfect market approach to the analysis of financial markets postulates that financial services are bought and sold in an anonymous manner, and the only information transfer consists of signals given by movements in prices. In this Arrow-Debreu world there is no need for financial intermediaries, as borrowers would obtain their loans directly from depositors. We have learned from Modigliani and Miller (1958) that in such a world, the financial structure of a firm does not matter. Nevertheless, one can find many reasons in the literature for why the Modigliani/Miller theorem does not hold in the real world, especially in financing innovations (see e.g., Stoneman 2001, Goodacre and Tonks 1995). The role and the positive impact of VC in financing innovations are well-understood in the meantime. However there is a lack of empirical evidence for whether a bank-based financial system has a negative impact on early-stage VC investments. The development of the different financial systems (market- versus bank-orientated) "*reflects, at least in part, politics, history and path-dependent evolution rather than economic inevitability*" (Black and Gilson 1998, p.244), but the systems can be seen as given for each country.

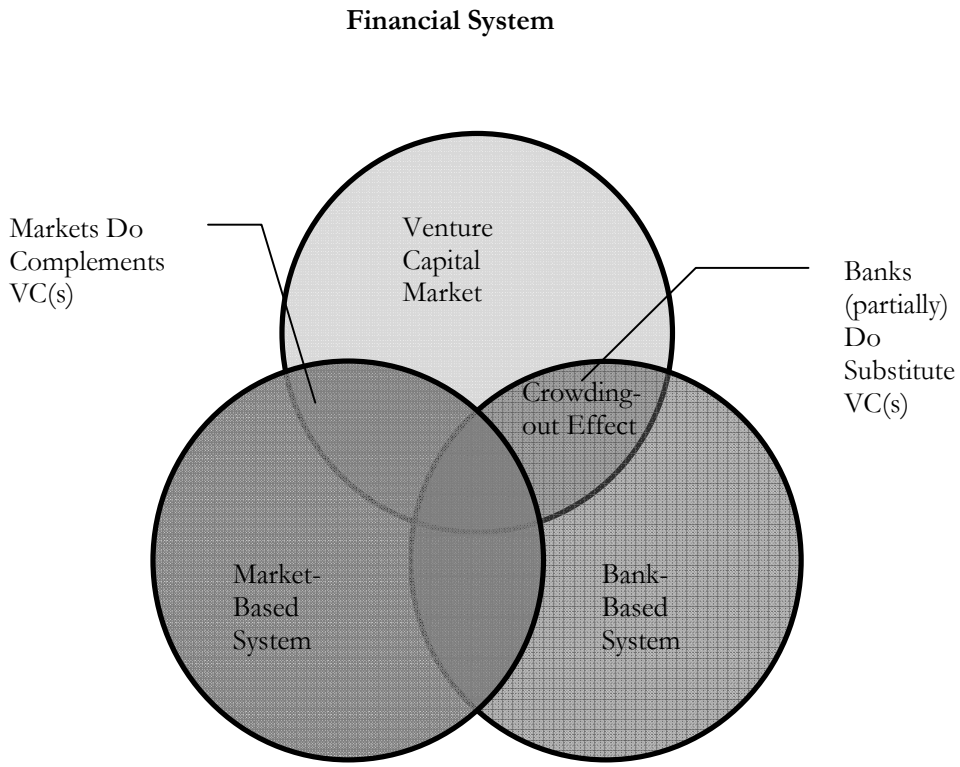
A bank could crowd out early-stage VC in a bank-based system due to the similarities in their business models; although banks provide external capital and the VCs provide equity, they are, to some extent, substitutes rather than complements. Both provide capital and are able to generate economies of scale when monitoring firms. Stulz (2000) claims that banks are effective in financing innovative activities that

require staged financing because banks can credibly commit to provide additional funding as the project develops (Beck/Levine 2002). Nevertheless, the VC is obviously more specialized in financing innovative firms, and, through their equity stake and the associated level of control (as mentioned above), VCs are more effective than banks in financing innovations. Indeed, there are problems that banks particularly face when financing innovative projects. Due to fixed interest payments, banks would not participate in the high returns in the case of a successful outcome. Banks are therefore more concerned with the probability of failure when calculating the price of a loan. In this context, Stiglitz and Weiss (1981) analyze why credit rationing could result instead of a higher interest rate that clears the market. The effects of moral hazard and adverse selection in debt markets explain why lenders may deny a loan agreement even if the project is promising. Given asymmetrically distributed information about the risk characteristics and default probabilities of firm's investment projects, lenders may ration credit rather than accept a higher interest rate that clears the market because an increase in the interest rate induces low-risk borrowers to exit the pool of applicants first. In addition, borrowers whose actions cannot be monitored by lenders have an intrinsic incentive to invest in risky, higher-return projects that increase the probability of bankruptcy. It is primarily because of this moral hazard problem that equity rather than debt is considered to be the natural source of finance for firms investing in risky R&D projects (Kukuk and Stadler 2001). Powerful banks use their close relationships with well-established firms to prevent the entrance of newcomers. Hence, established firms are protected, due to higher barriers to entry (Hellwig 1991). The argument of Gerschenkron (1963) and Boot et al. (1993) that banks could mitigate the problem of moral hazard by building up long-run relationships with firms is not relevant in terms of innovative start-ups, which suffer particularly with regard to a lack of capital.

Audretsch and Lehmann (2004) empirically analyzed whether debt and equity are complements or rather substitutes in financing young high-tech firms. Use of a dataset of the firms listed on the Neuer Markt in Germany reveals that they suffer from lower performance as long as finance is restricted to traditional banks. They also point out the necessity for exchange segments for fast-growing firms because venture capital and debt provided by banks are found to be substitutes rather than complements. This paper follows their approach and holds that banks and VCs are rivals in terms of their business models. Thus, the following empirical analysis includes the size of the banking sector in each country to investigate the first hypothesis.

Hypothesis 1: Bank-based systems prevent VC investments, as banks are, to some extent, substitutes.

Figure 4.1 Venture Capital Embedded in the Financial System



Source: Own Illustration

The aim of the VCs is to create value and to exit via a buyout or an initial public offering (IPO). An exit via an IPO is the most profitable exit option for the investor and the entrepreneur. This exit option could be one further reason why the VC industry has more weight in the US than in Europe. The stock market for new high-tech firms in the US is much better developed and enables many more IPOs than in Europe. This ensures much higher average returns on VC investments in the US than in Europe. On average a VC in the US yields returns of 26% p.a. for a ten-year investment to 2004 in comparison to 6.3% in Europe (EVCA, NVCA). A study by Hege et al. (2009, 2006) supports these results and shows that US venture capital firms show a significantly higher performance on average than their European counterparts both in terms of type of exit and rate of return. The study finds that US venture capitalists outperformed their market benchmark by a median annualized return of 63 percent, whereas their European counterparts underperformed their benchmark by 20 percent (Hege et al. 2006, p. 543). Black and Gilson point out the implicit contract between the outside investor who invests in a VC limited partnership. This implicit contract demands a successful exit strategy and a need to exhibit a better performance than other VCs and

improve the reputation. This reputation has a signal effect on both the outside investor and potential portfolio companies. The outside investor recycles funds from less successful to more successful VCs.

The net present value of a portfolio firm, higher in a market-based economy, is higher ex ante, due the higher probability of a remunerative exit via an IPO. However, Black and Gilson also highlight the implicit contract over future control between the VCs and the entrepreneur, which is not imitable in a bank-based economy. An IPO ensures that the entrepreneur alienates the control rights he gave up as the VCs got on board. This incentive for the entrepreneur is much stronger in market-based financial system than in a bank-based system, as the core requirement for entrepreneurial activity is that an entrepreneur be free in his decision making:

"In short, the venture capital fund´s special control rights end at the time of an IPO, leaving the fund with only the weaker control rights attendant to substantial stock ownership. Even this control will diminish over time as the venture capital fund reduces its remaining stock position. Control becomes vested in the entrepreneur, who often retains a controlling stock interest and, even if not, retains the usual broad discretion enjoyed by chief executives of companies without a controlling shareholder. The opportunity to acquire control through an IPO exit if the company is successful gives the entrepreneur a powerful incentive beyond the purely financial gain from the increased values of her shares in the firm. In effect, the prospect of an IPO exit gives the entrepreneur something of a call option on control, contingent on the firm´s success. Contras this outcome with what the entrepreneur receives when the venture capital provider exits through sale of the portfolio company to an established company. As in an IPO, the entrepreneur receives cash or the more liquid securities of a publicly traded acquirer. Control, however, passes to the acquirer, even if the entrepreneur remains in charge of day-to-day management. Thus, if an IPO exit is not available, the entrepreneur cannot be given the incentive of a call option on control exercisable in the event of success. Exit through an IPO is possible only in the presence of a stock market; its role in the contract between the venture capitalists and the entrepreneur links the venture capital market and the stock market." (Black/Gilson 1998, p.261)

In this context, I state my second hypothesis.

Hypothesis 2: Market-based financial systems stimulate VC investments.

4.4 Empirical Analysis

Empirical results from a macroeconomic perspective that explain the determinants of VC via panel analysis are relatively scarce. Jeng and Wells (2000), Schertler (2003, 2004), Romain and Van Pottelsberghe (2004a, 2004b) have done similar analysis but for different countries, time periods and, for the most part, using different variables. This analysis is the first which includes the size of the banking sector to determine whether a more bank-based financial system has a negative impact on early-stage VC investments.

4.4.1 Descriptive Statistics

As mentioned above, early-stage VC capital investments made in Europe from 1995 to 2006 differ profoundly across European countries and with the US. In Sweden, early-stage VC investments in 2006 amount to upwards of 0.056 percent of GDP; in Greece, early-stage VC scarcely exists. I apply a GLS panel analysis to determine if the explanations formulated by the two hypotheses are, inter alia, responsible for such huge differences in the amount of early-stage risk capital in 15 European countries and the US. The analysis includes Austria, Belgium, Germany, Denmark, Finland, France, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, the United Kingdom and the United States from 1995 to 2006. These countries have been selected because of their similar per capita income, available data and the fact that an analysis of this sample of countries has never been done before. In Eastern Europe, VC hardly played a role in the observed time period.

Table 4.1 Early VC Investments in Selected Countries (Amount in % of GDP)

TIME/ GEO	Belgium	Denmark	Germany	Ireland	Greece	Spain	France	Italy	Netherlands
1995	0.003	0.002	0.005	0.002	0.003	0.004	0.002	0.005	0.024
1996	0.009	0.002	0.005	0.005	0.006	0.002	0.008	0.005	0.028
1997	0.014	0.002	0.01	0.002	0.004	0.004	0.007	0.007	0.045
1998	0.061	0.008	0.024	0.026	0.004	0.009	0.02	0.014	0.047
1999	0.089	0.019	0.05	0.045	0.015	0.016	0.038	0.013	0.089
2000	0.105	0.02	0.08	0.106	0.007	0.032	0.08	0.045	0.089
2001	0.038	0.085	0.055	0.032	0.021	0.016	0.038	0.023	0.041
2002	0.041	0.074	0.026	0.021	0.008	0.015	0.026	0.005	0.043
2003	0.014	0.05	0.014	0.024	0.007	0.007	0.025	0.004	0.007
2004	0.016	0.084	0.016	0.019	0.002	0.008	0.025	0.002	0.008
2005	0.02	0.052	0.014	0.022	0	0.013	0.027	0.002	0.002
2006	0.012	0.015	0.011	0.015	0.001	0.027	0.03	0.002	0.012

Austria	Portugal	Finland	Sweden	United Kingdom	Norway	United States	TIME/GEO
0	0.005	0.008	0.003	0.003	0.005	0.04	1995
0	0.001	0.009	0.003	0.004	0.005	0.05	1996
0.002	0.011	0.008	0.002	0.008	0.003	0.056	1997
0.006	0.012	0.053	0.011	0.014	0.009	0.076	1998
0.007	0.007	0.056	0.099	0.018	0.02	0.153	1999
0.029	0.024	0.103	0.085	0.101	0.057	0.268	2000
0.02	0.012	0.101	0.094	0.056	0.034	0.086	2001
0.013	0.007	0.069	0.093	0.035	0.036	0.038	2002
0.013	0.039	0.058	0.061	0.038	0.028	0.034	2003
0.007	0.024	0.026	0.08	0.046	0.015	0.036	2004
0.012	0.038	0.044	0.05	0.046	0.028	0.038	2005
0.003	0.009	0.027	0.056	0.218	0.013	0.041	2006

Source: Eurostat

4.4.2 Variables[23]

The dependent variable is early-stage VC investments. The VC data are available from Eurostat.[24] Hence, following their definition, early-stage means the sum of seed and start-up risk capital. The variable is scaled by gross domestic product at market prices.

The explanatory variables are proxies for the financial system, technological and growth opportunities, as well as the macroeconomic and entrepreneurial environments. Including the amount of VC investments in the later-stage (expansion and replacement capital) also makes sense, considering the evolution of the VC markets. Evolution of a VC market means that it seems logical to assume that in the beginning, VCs prefer to invest in less risky projects such as already-existing firms, which have a successful business model and need VC to assure growth opportunities. VCs need time to build-up expertise and confidence. Building a track record (e.g., building trust) is essential for convincing potential investors to commit money to a VCs (Schertler 2002). Successful exits of portfolio firms enhance reputation and enable economies of scale and syndication with other VCs (Tykvova and Walz 2006) thus allowing the VCs to invest in risky, early-stage investments. Zarutskie (2010) determines that in seed stage VC funds, having a founding venture capitalist team with both venture investing experience and experience managing a start-up is the strongest predictor of fund performance. First-time seed stage funds with such founding teams strongly outperform their counterparts. An additional aspect is that in a more mature VC market such as the US, VC portfolios are on average larger and provide better options for diversification in early- and later-stage VC investments.

To measure the weight of the banking sector, I follow the approach of Levine and Zervos (1998). The variable banking sector equals the value of loans made by banks to private enterprises divided by GDP. Specifically, I divided line 22d by 99b from the IMF´s International Financial Statistics. The market capitalization of listed companies (in % of GDP) represents the size of the market-based system. Market capitalization (also known as market value) is the share price times the number of shares outstanding. Listed domestic companies are the domestically incorporated companies listed on the country's stock exchange(s) at the end of the year. Listed companies do not include investment companies, mutual funds or other collective investment vehicles. An increase in interest rates should positively affect the demand from entrepreneurs for early-stage VC. Conversely, if the supply effect is higher – i.e., the VCs invest more when interest rates fall –, the coefficient should be negative. I use the interest rates of ten year government bonds and expect a positive sign as Romain and Van Pottelsberghe (2004a) find in their analysis based on a panel data set of 16 OECD countries from 1990 to 2000. The expansion of an economy, measured as real GDP per capita growth, may affect the opportunities for firm growth and the survival rate of potential portfolio companies.

[23] For a more detailed data definition see appendix.
[24] http://epp.eurostat.ec.europa.eu/tgm/web/table/description.jsp

High-tech patent applications and research and development (R&D) expenditures represent both technological ability and innovation activities. Patents reflect a country's inventive activity. Patents also show the country's capacity to exploit knowledge and translate it into potential economic gains. In this context, indicators based on patent statistics are widely used to assess the inventive performance of countries (Eurostat). I differentiate the variable patent applications, using high-tech patent applications to the European Patent Office scaled by population assuming that the later delivers better results to explain early-stage VC investment because VCs are interested in investing in fast growing, high-tech sectors such as information and communication technologies, biotechnology and nanotechnology. R&D expenditures from the public and private sectors represent the creation of new knowledge. In the regression, high-tech patent applications and R&D expenditures represent the technological opportunities (TO) for each country.

I use self-employment rates as a percentage of total civilian employment to measure entrepreneurial activity or spirit. One has to handle this proxy with care because it includes all types of self-employment. Numerous entrepreneurs are not relevant in determining VC demand because of their less innovative business models. Moreover, becoming an entrepreneur can be triggered from the demand or the supply side of entrepreneurship. Being involved in an entrepreneurial activity could be a necessity; there are simply no other options for earning a living, and there is no comparative assessment to be made. However, the countries in the panel analysis are high-income countries, and we can assume that the perception of people who start a business is opportunity-driven in the sense that they have the opportunity of an alternative occupation as an employee.

The corporate tax rate negatively influences the value of the potential portfolio company, as future gains have a higher discount rate and could negatively affect the supply side of VC. I also expect a similar negative effect for labor costs and employment protections for regular employment on early-stage VC investments. Annual unit labor costs (ULCs) are calculated as the ratio of total labor costs to real output.

4.4.3 Model

Following the model employed by Jeng and Wells (2000) and Romain and Van Pottelsberghe (2004a), I created a supply and a demand function for early-stage venture capital. I assume that the early-stage venture capital supply (equation (1)) is driven by the level of later-stage VC investments, the corporate tax rate, the relative size of stock market capitalization (relative to GDP), labor costs, the banking sector and GDP growth. Equation (2) shows the demand function. I expect later-stage VC, corporate tax rates, technical opportunities, stock market development, GDP growth, entrepreneurial activity and the growth of interest rates to influence the demand of early-stage VC. The variable technical opportunity is measured by high-tech patent applications and all R&D expenditures.

$$(1)\quad VC^{S}_{early_{it}} = a_0 + a_1 Returnpercentage + a_2 VC_{later_{it}} + a_3 Tax_{it} + a_4 Stockmarket_{it} + a_5 GDPGrowth_{it} + a_6 Labor\,costs_{it}$$

$$(2)\quad VC^{D}_{early_{it}} = b_0 + b_1 Returnpercentage + b_2 VC_{later_{it}} + b_3 Tax_{it} + b_4 TO_{it} + b_5 Stockmarket_{it} + b_6 GDPGrowth_{it} + b_7 HRST_{it} + b_8 Banks_{it} + b_9 Selfemployment_{it} + b_{10} Interest_{it}$$

where in the equilibrium

$$(3)\quad VC^{S}_{early_{it}} = VC^{D}_{early_{it}} = VC_{early_{it}} funds$$

hence the regression equation

$$(4)\quad VC_{early_{it}} funds = \gamma_0 + \gamma_1 VC_{later_{it}} + \gamma_2 Tax_{it} + \gamma_3 TO_{it} + \gamma_4 Stockmarket_{it} + \gamma_5 GDPGrowth_{it} + \gamma_6 Labor\,costs_{it} + \gamma_7 Banks_{it} + \gamma_8 Selfemployment_{it} + \gamma_9 Interest_{it} + \mu_t + \varepsilon_{it}$$

To obtain (4), I solve the supply equation for the return percentage and substitute this expression into the demand equation. The index i represents the country, t represents time and μ_t is a time specific unobserved fixed effect (see Wooldridge 2002). The cross-section F-test and cross-section Chi-Square test do not reject the null hypothesis and indicate no country specific effect, unlike the F-Period test, which strongly rejects the null hypothesis. Therefore I use a one-way GLS model with time specific fixed effects. Taking first-differences (Δ) for each variable in equation (4) is necessary because different unit root tests indicate non-stationarity. Repeating the tests using first-differences variables leads to a strong rejection of the null hypotheses and hence indicates stationarity. Because the economic impacts of R&D expenditures and patent applications are not immediate, I include a one year time lag for each (-1).

$$(5a)\quad \Delta\left(VC_{early_{it}} funds\right) = \gamma_0 + \gamma_1 \Delta\left(VC_{later_{it}}\right) + \gamma_2 \Delta\left(Tax_{it}\right) + \gamma_3 \Delta\left(TO_{it}\,(-1)\right) + \gamma_4 \Delta\left(Stockmarket_{it}\right) + \gamma_5 \Delta\left(GDPGrowth_{it}\right) + \gamma_6 \Delta\left(Labor\,costs_{it}\right) + \gamma_7 \Delta\left(Banks_{it}\right) + \gamma_8 \Delta\left(Selfemployment_{it}\right) + \gamma_9 \Delta\left(Interest_{it}\right) + \mu_t + \varepsilon_{it}$$

Table 4.2 Descriptive Statistics

	VC Early Stage[1]	VC Later Stage[1]	High-tech patents[2]	R&D Expenditure[1]	Stockmarketcap[1]	Banking Sector[4]
Mean	0.030411	0.087177	28.63113	1.868703	75.62451	0.923265
Median	0.018500	0.065000	23.60650	1.839000	66.58178	0.870028
Maximum	0.268000	0.737000	127.9930	4.250000	268.3272	1.922591
Minimum	0.000	0.000000	0.150000	0.433900	12.89032	0.306905
Std. Dev.	0.035949	0.085254	27.17411	0.856612	44.82066	0.358782
Sum	5.839000	16.73800	5497.176	358.7910	14519.91	177.2669
Sum Sq. Dev.	0.246836	1.388248	141040.5	140.1528	383698.3	24.58639
Observations	192	192	192	192	192	192
Cross sections	16	16	16	16	16	16

	GDP Growth[3]	Corporate Tax Rate[3]	Interests[3]	Laborcosts[5]	Self-employment[7]	Strictness of Employment Protection
Mean	3.049316	33.87031	5.420858	0.597112	16.25625	2.215313
Median	2.869052	34.00000	4.973334	0.612636	13.10000	2.250000
Maximum	11.49460	56.80000	17.27000	0.726734	46.10000	4.330000
Minimum	-0.931428	12.50000	3.320833	0.338205	7.100000	0.210000
Std. Dev.	1.835078	7.046597	1.899628	0.085724	8.935133	0.898967
Sum	585.4688	6503.100	1040.805	114.6455	3121.200	425.3400
Sum Sq. Dev.	643.1945	9484.016	689.2403	1.403575	15248.79	154.3552
Observations	192	192	192	192	192	192
Cross sections	16	16	16	16	16	16

[1] in % of GDP
[2] per million inhabitants
[3] in %
[4] value of loans made by banks to private enterprises/GDP
[5] quotient of total labor costs and real output
[6] % of active persons in the age class of 25-64 years
[7] % of total civilian employment

4.4.4 Regression Results

The results of the regressions are presented in table 4.3. Models 1 to 11 show the separate regression results for each variable. Models 12 and 13 include all of the variables that were statistically significant in models 1 to 11. I have separated R&D expenditures and high-tech patent applications, due high correlation.

Using the estimated generalized least squares panel method (EGLS) with time-specific fixed effects and a heteroksedasticity consistent covariance matrix estimator that provides the correct estimates of the coefficient covariances in the presence of heteroskedasticity, which is derived from White (1980), the estimation results support the two hypotheses derived in section 3. The most important estimation result is the negative impact of the banking sector on VC investments. Whether the banking sector is the sole explanatory variable (as in model 2) or is analyzed in conjunction with control variables (as in models 12 and 13), the corresponding coefficients from each model are significant. High-value loans made by banks to private enterprises seem to serve as substitutes for early-stage VC investments, which is similar to the results found by Audretsch and Lehmann. The incentive for a bank to provide a start-up capital to entrepreneurs such as Steve Jobs, Bill Gates or Mark Zuckerberg for a new business is quite weak. The risk of failure is high, and the bank's ability to participate in a successful deal is limited by the interest rate. A further reason for the negative coefficient could be an indirect effect of the structure of the VC market in Europe. One can observe an increasing number of bank-dependent VCs in Europe, but compared to independent VCs, they are less frequently involved in early-stage investments (Hirsch and Walz 2006; Hellmann et al. 2008).[25] Stock market capitalization, as a proxy for a market-based financial system, is positively associated with early-stage VC investments. The coefficients from each model that includes the market capitalization of listed companies are highly significant. This result conforms to Hypothesis 2 and the extant empirical results, which show that vibrant stock markets are important because of the greater chance of a lucrative exit strategy for VCs through an IPO. Moreover, the average effort of the entrepreneur is a result of the implicit contract regarding future ownership in a market-based system is greater than in a more bank-based system. This empirical result supports the strand of the financial literature that postulates that a market-based financial system is more conducive to financial innovations, assuming that VCs are better at selecting and promoting young and innovative entrepreneurs. An increase in the ten-year interest rate is associated with an increase in VC investment levels. This finding supports the former empirical result that the demand effect is clearly stronger than the supply-side effect.

The panel analysis also supports the view that later-stage VC is essentially a precondition for early-stage VC, and path dependence is highly relevant. The adjusted R-squared of 0.5 is the highest of all of the models with one regressor.

[25] Hellman et al. (2008) simply show that the probability is greater that independent VCs will invest in early-stage deals compared to bank dependent VCs. In absolute terms, early-stage VC deals or investments can increase with an increasing number of bank-depending VCs.

Table 4.3 Regression Results/Method: Estimated Generalized Least Squares Panel Method (EGLS)/Fixed Effects Period

	VC Early Stage (Endogenous Variable)												
GLS Model	1	2	3	4	5	6	7	8	9	10	11	12	13
Exogenous Variable													
Δ VC Later Stage	0.1723***											0.1728***	0.156***
	(17.49)											(19.13)	(17.36)
Δ Banking Sector		-0.0084***										-0.010**	-0.013***
		(-2.19)										(-2.03)	(-2.37)
Δ Stockmarketcap		0.0001***										0.0001***	0.0002***
			(3.29)									(5.34)	(10.94)
Δ Interests				0.0037***								0.0032***	(0.004)***
				(8.37)								(11.50)	(12.82)
Δ RuDexpenditure (-1)					0.037***								0.037***
					(6.09)								(7.87)
Δ Self-employment						0.002***						0.0001	-0.0001
						(5.44)						(0.23)	(-0.10)
Δ High-Tech Patents (-1)							0.00047***					0.0002***	
							(12.38)					(6.19)	
Δ GDP Growth								-0.0002					
								(-0.52)					

GLS Model	1	2	3	4	5	6	7	8	9	10	11	12	13
Δ Corporate Tax Rate									-0.0021				
									(-0.63)				
Δ Strictness of										0.009			
Employment Protection										(1.48)			
Δ Laborcosts											0.095***	0.078***	0.081***
											(3.06)	(2.62)	(2.72)
Constant	0.0011***	0.0025***	0.0016***	0.0039***	0.0023***	0.0021***	0.0022***	0.0021***	0.0021***	0.0022***	0.0013***	0.0012*	0.0009
F-Statistics	38.15***	5.99***	6.56***	14.85***	5.63***	6.43***	5.49***	5.71***	5.89***	8.81***	7.47***	115.30***	71.74***
Durbin-Watson Stat.	1.9413	1.9525	1.9501	2.004	1.989	2.231	1.989	1.988	1.979	2.014	2.048	1.930	2.014
Adjusted R-Squared	0.700	0.287	0.259	0.499	0.225	0.255	0.220	0.228	0.235	0.232	0.289	0.920	0.889
Observations	176	176	176	176	176	176	176	176	176	176	176	160	160
Period Fixed Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: ***, **,*denotes significant at the 1, 5 and 10 per cent level, respectively. Absolute t-values are given under the coefficients.

For early-stage investors, a trade sale to a later-stage investor is the most common exit strategy. These two investment stages are complements and round out the VC business model. The track record of a VC company is crucial for attracting outside investors and entrepreneurs. Technological and innovation capacities, namely, R&D expenditures, are highly significant. Patents signal the innovation capacity of an entrepreneur to VCs and ensure legal certainty. Hence patent applications, particularly those of high-tech firms, are the first step in attracting VCs. One primary explanation of how R&D expenditures spur the demand of VC is that researchers working in firms and public entities entrain their acquired knowledge and use it to found their own start-ups. The results indicate that the self-employment rate, which reflects the entrepreneurial climate and institutional support and the accompanying low entrance barriers, matters. It is worth noting that the results for the self-employment rate are heterogeneous. While in model 6 the coefficient is significant, this effect disappears in models 12 and 13, which have fewer observations.

One can argue that employment protections increase entrance barriers. However, the estimation results do not support this view. Due to the nature of high-tech investments involving highly qualified staff, employment protections do not play a significant role because the risk of unemployment is negatively correlated with the level of education. Concerning labor costs, I concur with Schertler's argument that the capital ratio of potential portfolio firms is relatively high and explains why the coefficient of the variable is positive and significant.

The result concerning the GDP growth rate agrees with the results of Jeng and Wells, who find no impact, while Gompers and Lerner for the US and Romain, respectively, and Van Pottlesberghe for the OECD countries do observe such an impact. The coefficient of the corporate tax rate is negative but not significant. The results are robust in terms of significance with time lags of 1 for all variables. Additionally, in estimates of the models using panel GLS without period fixed effects the same variables are significant.

4.5 Conclusions

Young firms with between 10 and 49 employees face specific challenges in obtaining capital to realize their innovative ideas as marketable goods and services, due to moral hazard, adverse selection and lack of collateral, particularly in Europe. VC is an appropriate solution to alleviate these problems. However, in terms of relative volume, the differences in the amounts of early-stage VC investment attracted by various European countries is enormous.

This is the first analysis that includes the relative size of the banking sector to produce evidence regarding whether, as is suggested in the predominant theoretical financial literature, the negative impact of a more bank-based financial system can withstand the empirical evidence and thus provide an additional piece of the financial puzzle concerning VC. The fundamental argument supplied by Black and Gilson argues that banks are not able to duplicate the implicit contract regarding future control as a market-based system can. Additionally, a more market-based system provides more lucrative exits via IPOs. Whereas stock markets are complements for VC, banks are substitutes. The results in this paper support this view.

It is beyond question that the factors that stimulate early-stage VC are manifold and interdependent. However, the policy conclusion might be that bank-based economies, such as that of Germany, which has a broad knowledge base, need other policy instruments to stimulate VC (e.g., instruments similar to those employed in the US). Policy makers in more bank-based financial systems must focus their attention on instruments that are able to compensate for the lack of finance available to high-potential firms. To clear the way, public policy should enhance the incentives for banks to enter the early-stage VC market to loosen the financial constraints on innovative entrepreneurs seeking capital.

A further step to expand early-stage VC investment would be to support a single European stock market, which would enable an investment exit via IPO and achieve higher returns for VC investments in Europe. A European stock market segment, such as the AIM in the UK, where investors receive essential tax benefits if they invest in companies traded on AIM, is achievable. Moreover, the variables under consideration interact, and potential efficiency gains can be realized by improved networking between the institutions within the national innovation system, e.g., universities, greenfield investors (e.g., alumni) and VC companies. An interesting subject to be investigated in terms of stimulating early-stage venture capital markets is to examine the role of government programs or publicly dependent VCs. Are publicly funded VCs capable of stimulating the VC market? If publicly funded VC is required to develop VC markets, at what time would public assistance be useful and when could it become redundant? Depending on the composition of VC providers in different countries, one could expect varying risk profiles in investment behavior and government structures to protect investors. More research may be done on this subject. A comprehensive analysis of the policy instruments used in European countries in the past may be useful to find the best approach. Such an analysis should include cost-benefit comparisons and take relevant country specific terms into account. Europe, with its heterogeneous conditions between its different countries, may be helpful for finding the most appropriate solutions.

5. Policy Implications

ICT has changed the world along with diffusion of the internet in particular since the early 1990s. The influence of the mass-distribution of the internet on the social, political and economic lives of nearly all citizens is enormous and still rising. Of course, the umbrella term of ICT includes much more than merely the internet. However, the internet forms the infrastructure, among others for other areas of ICT, such as radio, TV, (mobile) phones, hardware and software for computers and networks and satellite systems or is complementary to them. Networking as an internet characteristic permits not only information and knowledge exchange in near-real-time, but also opens up new virtual markets, services and products. The internet gives birth to many services and increases the benefit of present products and services in nearly any business sector. This effect is increased by globalization. Country borders continually lose in importance for development of new markets. The market places span the entire world and the value-added chains are split up internationally while national economies have long been highly interdependent.

Services by mobile phone, also referred to as apps, are now part of the everyday lives of a rapidly increasing number of private users. Soon, digital services will also be comprehensively used by companies to generate individual and macroeconomic efficiency increases and higher competitiveness.

The economic policy at the time also recognized the basic importance of ICT. The Federal government included important future trends in its promotional policy with the report on future projects of the high-tech strategy (BMWi 2012a, b). While the area of demand of ICT is explicitly named in high-tech strategy, it also becomes clear that ICT holds an outstanding importance for implementation of the objectives in all other identified areas of demand as well. More efficient energy supply or development of smart electricity grids, so-called "Smart Grids" will only be possible with the corresponding ICT to efficiently control offer and demand. In an aging society, ICT will also be important for medical care. Even now, ICT increases mobility or saves distances. ICT has become integral to the automotive and engineering sectors, two of the most important industry sectors in Germany, increasing value generation in production and turning products smarter. This means that the produced goods are able to communicate directly with the user or with other linked units for the user's benefit due to their embedded sensors and memories. Many other areas that may be named, such as e-Government and e-Learning, are more widely distributed in the Scandinavian countries or the US than in Germany. They can be used to describe the revolutionary character of ICT in the medium and long term, which would, however, go too far in this place.

The number of promotional initiatives and the promotion volume of the EU and Germany for the ICT sector are considerable. The Federal Government alone describes 127 promotional measures for the ICT sector in the course of the next three years in the scope of its high-tech strategy or "Deutschland Digital 2015". They are aligned with the ICT promotional measures in the seventh research framework program of the EU. At approx. 9 million Euro, they are the largest promotional item in the EU research promotion agenda of 2007-2013. The diverse ICT promotional programs make comprehensive evaluation of all

measures near-impossible. This also has never been the purpose of this dissertation. However, this paper is able to offer a well-founded evaluation of cluster promotion as a promotional instrument as it is currently often used and considered important by political decision-makers based on the empiric analyses performed. It has shown that cluster promotion strongly focused on regional cooperation of companies in the ICT industry seems hardly sensible. Even though the term of cluster, depending on definition, cannot be reduced solely to spatial proximity of companies along the value-added chain of a sector, this aspect is nearly always a necessary prerequisite. The present patent analysis has shown that cooperation of companies with joint innovation output develops dynamically in parallel to the entire ICT sector over time in ICT cluster regions in Germany. However, this development applies for cooperations with a partner from outside of the region, while corporate cooperation among the companies inside the cluster is rather static over time. Opening to the outside is apparently important for successful development of a cluster region. It is noticeable that research institutions play an important role for the innovation process in the regions observed. A successful cluster also includes several large multi-national companies that support the cluster.

The results of the patent data analysis are supported by another analysis in which more than 200 ICT companies answered, among others, the question of whether they consider themselves an active part of the cluster.[26] The initially surprising result shows that ICT companies in a cluster exhibit rather weak growth while quickly growing ICT companies enter into targeted research cooperations with other companies but are not part of a cluster region. Apparently, clusters no longer necessarily coincide with cooperation within the cluster region. The possible benefits of a cluster region appear to be rather in a large pool of specialist workforce on site.

The author believes that the results of this study expose a weakness of current cluster promotion as pursued by the Federal government. The cluster of excellence competition, for example, is targeted at promoting the cooperation of science and research in selected regions with as much as 40 Mio. Euro per region. Generally, promotion of cooperation for highly innovative projects is, in fact, a promotional measure to be considered, but should not take place in a spatially limited area. Promotion based on the geographic location of companies does not appear sensible. Promotional initiatives of the EU, as well as partially the Federation, that promote cooperations under inclusion of SMEs independently of the region of the corporate seat, expand the options companies have for finding suitable partners and appear more sensible. It is probably the example of success of unique Silicon Valley that makes many political decision-makers believe that such success could be copied, since there seem to be good reasons for cluster promotion from an objective point of view as well. However, Silicon Valley was only possible at a specific time and in a specific industry in a specific country that led to a unique success in combination with other, partially unplannable factors, making it an example not very suitable as a blueprint. One example of an

[26] The companies were asked for self-assessment, followed by review of whether or not the company asked was actually part of the cluster initiative "Networks for Competence". Only if both prerequisites were met was the company deemed to be "active in a cluster".

important difference is the different mentality regarding self-employment between the US on the one hand and Germany or Europe on the other. The so-called entrepreneur is perceived differently in the US and in particular acceptance of "failure" is much higher there. An important factor that is connected to this is dealt with in the third analysis. Venture Capital (VC) is an important funding source for new companies in the US in general and in Silicon Valley in particular. VC frequently is spatially focused and can often be found in cluster regions – creating a cluster in the cluster – since the venture capitalist (VCs) needs to be present in many cases. As already discussed in the third analysis, this specialized capital provider plays a much larger role in the US. In Germany, this role is assumed by banks, using loan capital and hardly any venture or equity capital like the VCs does. The different risk preferences that result from the different approach of VCs to banks make it easier for an entrepreneur in the US, relatively speaking, to procure capital for a high-risk innovation. In addition to lower market entrance barriers, the expectations of success for the specialist capital provider are higher because he is able to estimate the innovation project more realistically based on his experience. He also increases the chances of survival with the know-how he contributes and the returns on VC are relatively higher in the US than in Germany. The benefit of clusters therefore should be estimated in the respective economic or national context. As described above, the companies in Silicon Valley are mainly funded by venture capital, which is hardly imaginable in Germany – among others due to the German banking system or finance system and the associated role of VCs.

To put it in a nutshell: Promotion of innovation projects between companies or companies and research facilities seems to be generally sensible in Germany. On the other hand, promotion according to region seems to make little sense in the ICT sector. The ICT sector has mostly removed its spatial barriers by novel methods of communication.

Small-scaled public start-up funding for a cluster secretariat may, in fact, be sensible, as may be acting as a networker for a strongly overproportionally represented industrial sector in a region. However, the networker should be linked super-regionally to be able to offer actual added value.

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Appendix to Chapter 2

Table A.2.1 Descriptive Statistics (Variables)

Variable	Description	Number/ Share in %	Source
Sales growth	Average annual revenue growth over the last five years $Y_{salesgrowth}$ = { 0 if y = no sales growth or negative growth; 1 if y > 0 ≤ 5 % sales growth; 2 if y > 5 ≤ 10 % sales growth; 3 if y >10 ≤ 20% sales growth; 4 if y > 20 % sales growth }	27/ 13.78 56/ 28.57 34/ 17.35 30/ 15.30 49/ 25.00	Survey
Sales	Annual Sales in Mio. Euro X_{sales} = { 1 if x_{sales} if ≤ 0,5 Mio. Euro; 2 if x_{sales} if > 0,5 ≤ 2,5 Mio. Euro; 3 if x_{sales} if > 2,5 ≤ 10 Mio. Euro; 4 if x_{sales} if > 10 Mio. Euro }	30/ 14.08 91/ 42.72 49/ 23.00 43/ 20.20	Survey
Research and Development (R&D)	Does the company operates in research and development: $X_{R\&D}$= { 0 if $x_{R\&D}$= No; 1 if $x_{R\&D}$= Yes }	134/ 65.69 70/ 34.31	Survey
Export ratio	Export share of total sales in % $X_{R\&D}$ = { 0 if x_{export} = 0%; 1 if $x_{R\&D}$ > 0% ≤ 20%; 2 if $x_{R\&D}$ > 20% }	60/ 29.85 94/ 46.77 47/ 23.38	Survey
Tax (municipal multiplier) rate	Business tax rate in 2008 at the company`s headquarters	213/ 100.00	Federal Statistical office

Venture Capital (VC)	The surveyed companies received venture capital and the question of added value for the company was given a positive response. $X_{VC} = \begin{cases} 0 \text{ if } x_{vc} = \text{No} \\ 1 \text{ if } x_{vc} = \text{Yes} \end{cases}$	167/ 86.97 25/ 13.03	Survey
Equity ratio	Equity ratio in % $X_{\text{equity ratio}} = \begin{cases} 1 \text{ if } x_{\text{equity ratio}} \text{ if } \leq 40\% \\ 2 \text{ if } x_{\text{equity ratio}} \text{ if } > 40\% \leq 80\ \% \\ 3 \text{ if } x_{\text{equity ratio}} \text{ if } > 80\ \% \end{cases}$	78/ 45.88 40/ 23.53 52 / 30.59	Survey
University town	Universities or colleges that offer a degree in (applied) computer science, automation technology, electrical engineering, information technology, communication technology, Embedded System Engineering, Mechatronics. $X_{\text{university}} = \begin{cases} 0 \text{ if } x_{\text{university}} = \text{No} \\ 1 \text{ if } x_{\text{university}} = \text{Yes} \end{cases}$	142/ 67.62 68/ 32.38	Rectors` Conference http://www.hs-kompass2.de
Cooperation	Occur collaborations with other companies or research institutions (for example universities or research institutions) in term of research and development of new products/ services ? $X_{\text{cooperation}} = \begin{cases} 0 \text{ if } x_{\text{cooperation}} = \text{No} \\ 1 \text{ if } x_{\text{cooperation}} = \text{Yes} \end{cases}$	30/ 61.90 80/ 38.10	Survey
Cooperation with business	Occur partnership with one or more other companies on research and development of new products/ services ? $X_{\text{cooperation company}} = \begin{cases} 0 \text{ if } x_{\text{cooperation company}} = \text{No} \\ 1 \text{ if } x_{\text{cooperation company}} = \text{Yes} \end{cases}$	149/ 70.95 61/ 29.05	Survey
Cooperation with universities	Occur collaborations with one or more universities or other research institutions in terms of research and development of new products/ services ? $X_{\text{cooperation university}} \begin{cases} 0 \text{ if } x_{\text{cooperation university}} = \text{No} \\ 1 \text{ if } x_{\text{cooperation university}} = \text{Yes} \end{cases}$	167/ 79.52 43/ 20.48	Survey
ICT business (firm) density	Active member of the Information and Communications (WZ 2008) on the date 31.12.2007 in the respective district or country-city resident asked where the company is divided by the total local businesses (in the city/ country of the surveyed company).	210/ 100.00	Federal Statistical Office
Actively involved in a cluster	For the variable is that the following three conditions had to be satisfied, i.e. Questions with Yes or active had to be answered, and the company`s headquarters is a city that belongs to the ICT Network "Competence Network Germany".		Survey and Homepage

	Question 1) Is the company a player in regional economic clusters? The term cluster are networks of closely cooperating companies, which are located in close proximity to each other meant, and whose activities are located along a spatial proximity to each other meant and complement their activities, along one or more value chains or are related to each other. So are there any other companies in your industry and in your area, that the company maintains close economic cooperation? $X_{\text{cluster participants}}$ { 0 if $x_{\text{cluster participants}}$ =No; 1 if $x_{\text{cluster participants}}$ = Yes Question 2) Is the company`s own perception of active participants in this cluster? Please make an assessment based on the scale. X_{activity}= { 1 if x_{activity} if active; 2 if x_{activity} if neutral; 3 if x_{activity} if not active In the case of $x_{\text{cluster participants}}$ = Yes and $x_{activity}$ = Active and measurement company based in a city of 15 ICT network regions is that the variable $x_{\text{active cluster participants}}$ takes the value 1 and otherwise zero. $X_{\text{active cluster participants}}$ { 0 if $x_{\text{active cluster participants}}$ = No; 1 if $x_{\text{active cluster participants}}$ = Yes	115/ 57.21 86/ 42.79 64/74.42 16/18.60 6/6.98 168/83.58 33/16.42	„Competence Networks Germany“: http://www.kompetenznetze.de/netzwerke/netzwerklisting_view?b_start:int=10&innovation_region=&innovation_range=4e86e0b55209450e39135a4fd7499a35 European Cluster Observatory http://www.clusterobservatory.eu/
Regional policy	Please evaluate the supporting effect of regional policy in a positive business development $X_{\text{regional policy}}$ { 0 if $x_{\text{regional policy}}$ if low; 1 if $x_{\text{regional policy}}$ if neutral; 2 if $x_{\text{regional policy}}$ if high	98/ 50.00 49/ 25.00 49/ 25.00	Survey
Access to human capital	Assessment of the companies surveyed by the availability of qualified personnel in the labor market for the company`s specific needs? $X_{\text{access to human capital}}$ { 0 if $x_{\text{access to human capital}}$ if low; 1 if $x_{\text{access to human capital}}$ if moderate; 2 if $x_{\text{access to human capital}}$ if high	82/ 44.81 80/ 43.72 21/ 11.47	Survey
Number of employees	$X_{\text{number of employees}}$ { 0 if x ≤ 10 employees; 1 if y > 10 ≤ 50 employees; 2 if y > 50 ≤ 250 employees; 3 if y > 250 employees	45/ 21.12 117/ 54.93 36/ 16.90 15/ 7.05	Survey

New product	The dummy variable takes the corresponding value of 1 if the interviewed companies have introduced in the last 3 years a completely new product or the value zero if not. $X_{new\ product}$ $\begin{cases} 0 \text{ if } x_{new\ product} = \text{No} \\ 1 \text{ if } x_{new\ product} = \text{Yes} \end{cases}$	114/ 54.29 96/ 45.71	Survey
Business age	in years	210/ 100.00	Survey
Regional ICT business (firm) density	Active member of the Information and Communications (WZ 2008) on the date 31.12.2007 in the respective district or county-city resident asked where the company is divided by the square kilometers of the respective district or county-city	210/ 100.00	Federal Statistical Office
Regional business (firm) density	All active companies at the date 31.12.2007 in the respective district or county-city resident asked where the company is divided by the square kilometers of the respective district or county-city	210/ 100.00	Federal Statistical Office
Relative share of ICT business (firms) in the region	Active member of the Information and Communications (WZ 2008) on the date 31.12.2007 in the respective district or county-city resident asked where the company is divided by all active companies in the respective district or county-city	210/ 100.00	Federal Statistical Office
Relative share of ICT business (firms) in the region compared to the relative share of total German	Share of active companies in information and communication (WZ 2008) on all companies in the date 31.12.2007 in the respective district or county-city resident asked where the company is divided by the share of all ICT companies of all enterprises in Germany	210/ 100.00	Federal Statistical Office
Herfindahlindex (employees)	The respective share of workers in the sector: • agriculture and forestry; • Producer. Industry excluding construction; • Construction; • Retail / Hospitality / Transportation; • Provision of financial and insurance services; • Real estate activities; • Professional / Scientific/ technical Services / otherwise. Services; • Public Administration / Defence / Social insurance / Education; • Art, entertainment, recreation, private households of all employees in each district or county-city resident questioned where the company is to be squared. All squared shares are added. It is generally assumed at a value H <0.10, a uniform concentration. Values on H> 0.18 show the concentration of a sector.	210/ 100.00	Federal Statistical Office
Regional ICT business (employment) density	Employees of the Information and Communications (WZ 2008) on the date 30.06.2008 in the respective district or county-city resident asked where the company is divided by the square kilometers of the respective district or county-city	210/ 100.00	Federal Statistical Office

Regional business (employment) density	Employees at the date 30.06.2008 in the respective district or county-city resident questioned where the company is divided by the square kilometers of the respective district or county-city	210/ 100.00	Federal Statistical Office
Relative share of ICT business (employees) in the region	Employees of the Information and Communications (WZ 2008) on the date 30.06.2008 in the respective district or county-city resident asked where the company is divided by the share of all ICT employees in Germany	210/ 100.00	Federal Statistical Office
Herfindahl (firns)	The respective shares in companies in the sectors • Mining and quarrying and earth; • Manufacturing; • energy supply; • Water supply • Construction • Trade, maintenance. and repair of automobile • Transportation and storage; • Hotels and restaurants; • Provision of financial and insurance service; • Real estate activities; • Freelance scientific.and technical. Services; • Other economic services; • Education; • Health and social work; • Art, entertainment and recreation; • Other service of all enterprises in each district or county-city resident questioned where the company is to be squared. All squared shares are added. It is generally assumed at a value H <0.10, a uniform concentration. Values of H> 0.18 show the concentration of a sector.	210/ 100,00	Federal Statistical Office
Relative share of ICT business (employees) in the region compared to the relative share of total German	Share of employees of the Information and Communications (WZ 2008) to all companies on the date 31.12.2007 in the respective district or county-city resident asked where the company is divided by the share of all ICT companies of all enterprises in Germany	210/ 100,00	Federal Statistical Office

Table A.2.2 Correlation Matrix

	Business age	Number of employee	Export ratio	Equity ration	Access to human capital	Cooperation business	Cooperation University	Regio-nal policy	University town	Tax	Regional ICT firm density	Actively involved in a cluster	New product	VC	R&D
Business age	1														
Number of employee	0.1335	1													
Export ratio	-0.1636	-0.0103	1												
Equity ratio	-0.0625	-0.1104	0.1113	1											
Access to human capital	-0.0188	-0.07	0.0406	0.0063	1										
Cooperation business	-0.0849	0.0523	0.1017	-0.0403	0.1191	1									
Cooperation university	-0.1136	0.0348	0.0679	-0.102	0.1419	0.3406	1								
Regional policy	-0.1892	-0.0723	-0.1703	-0.025	0.0699	0.0686	0.0662	1							
University town	-0.1704	0.0844	0.0168	0.0833	0.0513	0.1185	0.076	0.0453	1						
Tax	-0.0845	-0.0315	-0.0043	0.0699	0.0185	0.1353	0.1069	0.0828	0.638	1					
IKT Regional ICT firm density	-0.0011	-0.0865	-0.0018	0.0173	0.0413	-0.0985	-0.0601	-0.1432	0.026	0.1115	1				
Actively involved in a cluster	-0.036	0.1111	-0.0234	-0.0296	0.0189	0.1294	0.0841	0.0167	0.3351	0.2035	0.0067	1			
New product	-0.14	-0.0673	0.1216	0.0532	0.0624	0.2018	0.1247	0.0208	0.0318	-0.0072	0.0658	0.0948	1		
VC	-0.2568	0.0711	0.1833	-0.0869	0.0334	0.2038	0.1101	0.0295	0.1934	0.1072	0.0802	0.0091	0.0999	1	
R&D	-0.1875	-0.0503	0.2264	0.0731	0.1851	0.4919	0.4122	0	0.0645	0.0557	0.0407	0	0.3077	0.182	1

Table A.2.3 Statistical Information on the Responses of Surveyed Companies (Selection)

The companies surveyed are

Answer	Amount	
An single-site company without branch	115	54.25%
The headquarters of a company with branch(es)	75	35.38%
Branch, subsidiary company	20	9.43%
Other	2	0.94%
No answer	0	0.00%

The companies surveyed were

Answer	Amount	
A complete start-up company	167	79.15%
A takeover of an existing company	15	7.11%
A spin-off of an existing company	24	11.37%
A spin-off from a university	2	0.95%
A research institute	0	0.00%
Other	3	1.42%
No answer	0	0.00%

How many permanent employees are currently working in the company? (Please convert part-time workers to full-time employees (with ½, ¼ etc.))

Answer	Amount	
0 to 10	45	21.13%
More than 10 to 25	80	37.56%
More than 25 to 50	37	17.37%
More than 50 to 100	17	7.98%
More than 100 to 250	19	8.92%
More than 250 to 500	7	3.29%
More than 500	8	3.76%
No answer	0	0.00%

Compared with the number of employees from three years ago, the company now employs

Answer	Amount	
More employees	129	60.56%
Fewer employees	22	10.33%
About the same number of employees	56	26.29%
No answer	6	2.82%

What is the annual turnover of the company

Answer	Amount	
Less than 0.1 Mio. €	6	2.82%
More than 0.1 Mio. € to 0.5 Mio. €	24	11.27%
More than 0.5 Mio. € to 1 Mio. €	28	13.15%
More 1 Mio. € to 2.5 Mio. €	63	29.58%
More than 2.5 Mio. € to 5 Mio. €	33	15.49%
More than 5 Mio. € to 10 Mio. €	16	7.51%
More than 10 Mio. € to 50 Mio. €	29	13.62%
More than 50 Mio. € to 100 Mio. €	8	3.76%
More than 100 Mio. € to 500 Mio. €	4	1.88%
More than 500 Mio. €	1	0.47%

No answer	1	0.47%

What is the percentage of foreign sales to total sales (export earnings)?

Answer	Amount	
0%	60	28.17%
More than 0% to 20%	94	44.13%
More than 20% to 40%	28	13.15%
More than 40% to 60%	12	5.63%
More than 60% to 80%	4	1.88%
More than 80%	3	1.41%
No answer	12	5.63%

What is the annual average growth rate of the company's turnover in the last year five? If the company does not yet exist for five years, please indicate the average annual growth rate since the start of business

Answer	Amount	
No growth or negative growth	27	12.68%
0% to 2.5%	27	12.68%
More than 2.5% to 5%	29	13.62%
More than 5% to 10%	34	15.96%
More than 10% to 20%	30	14.08%
More than 20% to 30%	27	12.68%
More than 30% to 50%	8	3.76%
More than 50% (8)	14	6.57%
No answer	17	7.98%

Has the company been innovative in the past 3 years? That is, has completely new product been developed within the last 3 years and/or was there an improvement of an existing product instead and /or was a new technology introduced, which has substantially changed the production of an existing product and or was there an organizational improvement in the company? (It is important to assess from the perspective of your business. It does not matter if another company has already introduced this innovation)

Answer	Amount	
Yes (Y)	178	83.57%
No (N)	26	12.21%
No answer	9	4.23%

What kind of innovation(s) were there in the last 3 years?

Answer	Amount	
Completely new product (1)	96	45.07%
Improvement of an existing product (2)	103	48.36%
Introduction of a new technology which has substantially changed the production of an existing product (3)	74	34.74%
Organizational improvement (4)	70	32.86%

Does the company run research and development?

Answer	Amount	Percentage
Yes (Y)	134	62.91%
No (N)	70	32.86%
No answer	9	4.23%

Does the company run such research and development activities continuously or only occasionally?

Answer	Amount	
Continuously (1)	97	51.60%
Occasionally (2)	36	19.15%
No answer	55	29.26%

What was the expenditure on research and development as a percentage of total sales in 2008?

Answer	Amount	
0% (1)	2	1.06%
More than 0% to 2.5% (2)	8	4.26%
More than 2.5% to 5% (3)	24	12.77%
More than 5% to 7.5% (4)	21	11.17%
More than 7.5% to 10% (5)	19	10.11%
More than 10%	49	26.06%
No answer	65	34.57%

In the last 3 years has there been at least one application for a patent by the company or is one currently in the application stage?

Answer	Amount	
Yes (Y)	20	9.39%
No (N)	180	84.51%
No answer	13	6.10%

Is it possible for the company without further ado, to raise the necessary capital for new investments?

Answer	Amount	
Totally applies (1)	35	16.43%
Applies most of the time (2)	55	25.82%
Applies partially (3)	47	22.07%
Does not apply most of the time (4)	41	19.25%
Does not apply at all (5)	18	8.45%
No answer (6)	17	7.98%

How high is the equity ratio of the company?

Answer	Amount	
0% (1)	0	0.00%
More than 0% to 20% (2)	42	19.72%
More than 20% to 40% (3)	36	16.90%
More than 40% to 60% (4)	24	11.27%
More than 60% to 80% (5)	16	7.51%
More than 80%	52	24.41%
No answer	43	20.19%

Does the company currently receives venture capital or has it ever received any?

Answer	Amount	
Yes (Y)	33	15.49%
No (N)	167	78.40%
No answer	13	6.10%

Has the company filed one or several patents or developed a prototype at the time it received venture capital?

Answer	Amount	
Yes, one or more patents (1)	8	3.76%
Yes, one or more prototypes (2)	15	7.04%
Neither (3)	13	6.10%

Has the influence of the venture capital company basically brought an added value to the company in terms of additional know-how and / or additional networks? Please rate on a scale from 1 to 5.

Answer	Amount	
Very high (1)	0	0.00%
High (2)	10	6.45%
Moderate (3)	10	6.45%
Low (4)	5	3.23%
No added value (5)	6	3.87%
No answer	124	80.00%

What was or is the added value to the company by the venture capitalist (or venture capital company)?

Answer	Amount	
Additional patent application (s) (1)	0	0.00%
A higher revenue growth than previously (2)	7	3.29%
Additional know-how and/or networks with other companies (3)	16	7.51%
Other	2	0.94%

How is the availability of qualified personnel in the labor market for the company-specific needs assessed? Please rate on a scale from 1 to 5.

Answer	Amount	
Very high (1)	13	6.10%
High (2)	28	13.15%
Moderate (3)	82	38.50%
Low (4)	63	29.58%
Very Low (5)	20	9.39%
No answer	7	3.29%

Is the company a player in regional economic cluster? The term cluster means networks of closely cooperating companies, which are located in close proximity to each other and which are related or complement their activities, along one or more value chains. Are there other companies in your industry and your area, with which the company maintains close economic cooperation?

Answer	Amount	
Yes (Y)	87	40.85%
No (N)	116	54.46%
No answer	10	4.69%

Is the company, in their own perception, an active participant in this cluster? Please rate on a scale from 1 to 5.

Answer	Amount	
Very active (1)	19	10.86%
Active (2)	47	26.86%
Neutral (3)	16	9.14%
Little active (4)	5	2.86%
Not active (5)	0	0.00%

No answer	88	50.29%

Do collaborations with other companies or research institutions (e.g. universities or research institution) happen in terms of research and development of new products / services?

Answer	Amount	
Yes, there is cooperation in terms of research and development with other companies (1)	62	29.11%
Yes, there is cooperation in terms of research and development with research institutions (2)	45	21.13%
No, there is no cooperation in terms of research and development (3)	53	24.88%

Did one or more patents develop from there collaborations, which otherwise would have probably not been developed?

Answer	Amount	
Yes (1)	5	2.87%
No (2)	66	37.93%
No idea (3)	4	2.30%
No answer	99	56.90%

How high would you estimate the value of cooperation in terms of new innovations for products / services? Please rate on a scale from 1 to 5.

Answer	Amount	
Very high (1)	10	5.75%
High (2)	40	22.99%
Moderate (3)	25	14.37%
Low (4)	4	2.30%
Very low (5)	1	0.57%
No answer	94	54.02%

Are the partners located in close proximity (less than 30 kilometers) in terms of research and development of new products / services?

Answer	Amount	
All partners are located in close proximity (1)	21	9.86%
Most of the partner are located in close proximity (2)	33	15.49%
About half of the partners are located in close proximity (3)	22	10.33%
Few partners are located in close proximity (4)	32	15.02%
No partners are located in close proximity (5)	26	12.21%
No answer	79	37.09%

Please evaluate the supporting effect of politics on a positive business development. (Policies at regional level)

Answer	Amount	
Very high (1)	15	7.04%
High (2)	36	16.90%
Moderate (3)	49	23.00%
Little (4)	44	20.66%
Very little (5)	54	25.35%
No answer	15	7.04%

To what extent do barriers of large companies prevent or hinder an involvement in networks? Please rate on a scale from 1 to 5.

Answer	Amount	
Very high (1)	24	11.27%
High (2)	39	18.31%
Moderate (3)	44	20.66%
Low (4)	41	19.25%
Very low (5)	20	9.39%
No answer	45	21.13%

Table A.2.4 Estimation Results

Ordered Probit Regression Model 1		Number of observations:186		Pseudo R2 = 0.1195		
LR chi2(5) = 69.97		Prob > chi2 = 0.0000		Log likelihood = -257.7724		
Sales growth	Coefficient	Standard error	Z-Value	**P>z**	95% Confidence interval	
Business age	-.0609897	.0091906	-6.64	**0.000**	-.0790029	-.0429764
Number of employees	.3165917	.0989123	3.20	**0.001**	.1227272	.5104562
Tax	-.000909	.0014754	-0.62	**0.538**	-.0038007	.0019828
R&D	.5425875	.1725875	3.14	**0.002**	.2043223	.8808528
Export ratio	.2361641	.1152351	2.05	**0.040**	.0103075	.4620206
/cut1	-1.706588	.6725346			-3.024732	-.3884444
/cut2	-.5963969	.6642638			-1.89833	.7055363
/cut3	-.0451874	.6607479			-1.340229	1.249855
/cut4	.5102087	.6605765			-.7844974	1.804915
Ordered Probit Regression Model 2		Number of observations:186		Pseudo R2 = 0.1085		
LR chi2(5) = 63.54		Prob > chi2 = 0.0000		Log likelihood = -260.9885		
Sales growth	Coefficient	Standard error	Z-Value	**P>z**	95% Confidence interval	
Business age	-.0603334	.0091516	-6.59	**0.000**	-.0782701	-.0423967
Number of employees	.3020688	.0983381	3.07	**0.002**	.1093296	.494808
Tax	-.0007723	.0014746	-0.52	**0.600**	-.0036624	.0021178
New product	.3026719	.1621071	1.87	**0.062**	-.0150521	.6203959
Export ratio	.2859347	.1132449	2.52	**0.012**	.0639788	.5078905
/cut1	-1.794353	.6729164			-3.113245	-.4754615
/cut2	-.7207349	.6633193			-2.020817	.5793471
/cut3	-.1731732	.6601975			-1.467137	1.12079
/cut4	.3804453	.6601895			-.9135022	1.674393

Ordered Probit Regression Model 3		Number of observations:186		Pseudo R2 = 0.1106		
LR chi2(5) = 64.75		Prob > chi2 = 0.0000		Log likelihood = -260.381		
Sales growth	Coefficient	Standard error	Z-Value	**P>z**	95% Confidence interval	
Business age	-.0618713	.0091317	-6.78	**0.000**	-.079769	-.0439735
Number of employees	.3107915	.0984948	3.16	**0.002**	.1177453	.5038377
Tax	-.0001995	.0015092	-0.13	**0.895**	-.0031575	.0027585
Actively involved in a cluster	-.4769163	.2202052	-2.17	**0.030**	-.9085105	-.0453221
Export ratio	.290385	.1129803	2.57	**0.010**	.0689478	.5118223
/cut1	-1.784668	.6707472			-3.099308	-.4700272
/cut2	-.7163219	.6601817			-2.010254	.5776104
/cut3	-.166628	.6569734			-1.454272	1.121016
/cut4	.3946267	.6574733			-.8939972	1.683251
Ordered Probit Regression Model 4		Number of observations:186		Pseudo R2 = 0.1091		
LR chi2(5) = 63.87		Prob > chi2 = 0.0000		Log likelihood = -260.82192		
Sales growth	Coefficient	Standard error	Z-Value	**P>z**	95% Confidence interval	
Business age	-.0613678	.0091384	-6.72	**0.000**	-.0792788	-.0434567
Number of employees	.2841439	.0977754	2.91	**0.004**	.0925077	.4757802
Tax	-.0011152	.0014738	-0.76	**0.449**	-.0040038	.0017734
Cooperation with business	.3424893	.1754199	1.95	**0.051**	-.0013273	.6863059
Export ratio	.2745165	.1137165	2.41	**0.016**	.0516362	.4973968
/cut1	-201343	.6635541			-3313972	-.7128883
/cut2	-.9459341	.6525138			-2224838	.3329695
/cut3	-.398982	.6484976			-1670014	.8720499
/cut4	.1582757	.6482533			-1112278	1428829
Ordered Probit Regression Model 5		Number of observations:186		Pseudo R2 = 0.1040		
LR chi2(5) = 60.92		Prob > chi2 = 0.0000		Log likelihood = -262.29573		
Sales growth	Coefficient	Standard error	Z-Value	**P>z**	95% Confidence interval	
Business age	-.0605744	.0091465	-6.62	**0.000**	-.0785012	-.0426476
Number of employees	.2832274	.0977192	2.90	**0.004**	.0917014	.4747535
Tax	-.0010062	.0014711	-0.68	**0.494**	-.0038895	.0018772
Cooperation with university	.1779234	.19031	0.93	**0.350**	-.1950774	.5509242
Export ratio	.2939287	.1130518	2.60	**0.009**	.0723513	.5155061
/cut1	-1.995781	.6627146			-3.294678	-.6968843
/cut2	-.9274522	.651526			-2.20442	.3495153
/cut3	-.3870822	.6476245			-1.656403	.8822386
/cut4	.1608492	.6472055			-1.10765	1.429349

Ordered Probit Regression Model 6		Number of observations:186		Pseudo R2 = 0.1026		
LR chi2(5) = 60.05		Prob > chi2 = 0.0000		Log likelihood = -262.73291		
Sales growth	Coefficient	Standard error	Z-Value	**P>z**	95% Confidence interval	
Business age	-.0612239	.0092025	-6.65	**0.000**	-.0792605	-.0431872
Number of employees	.2849188	.0984276	2.89	**0.004**	.0920042	.4778334
Tax	-.0008947	.0019381	-0.46	**0.644**	-.0046932	.0029039
University town	-.0069739	.2224589	-0.03	**0.975**	-.4429853	.4290375
Export ratio	.3006077	.1128041	2.66	**0.008**	.0795157	.5216997
/cut1	-1.98943	.7558411			-3.470851	-.5080086
/cut2	-.9309366	.7488312			-2.398619	.5367455
/cut3	-.3923474	.7450972			-1.852711	1.068016
/cut4	.1575518	.7431499			-1.298995	1.614099

Ordered Probit Regression Model 7		Number of observations:181		Pseudo R2 = 0.1103		
LR chi2(5) = 62.98		Prob > chi2 = 0.0000		Log likelihood = -253.92001		
Sales growth	Coefficient	Standard error	Z-Value	**P>z**	95% Confidence interval	
Business age	-.0632476	.0092139	-6.86	**0.000**	-.0813064	-.0451887
Number of employees	.3225352	.0999876	3.23	**0.001**	.1265631	.5185074
Tax	-.0009424	.0015135	-0.62	**0.534**	-.0039087	.002024
Access to human capital	.1207442	.1079238	1.12	**0.263**	-.0907826	.3322709
Export ratio	.2843736	.1140255	2.49	**0.013**	.0608876	.5078595
/cut1	-1.951903	.6874061			-3.299194	-.6046118
/cut2	-.8728224	.6773946			-2.200491	.4548467
/cut3	-.3158601	.6727003			-1.634328	1.002608
/cut4	.2528832	.6720639			-1.064338	1.570104

Ordered Probit Regression, Model 8		Number of observations:186		Pseudo R2 = 0.1026		
LR chi2(5) = 60.07		Prob > chi2 = 0.0000		Log likelihood = -262.72076		
Sales growth	Coefficient	Standard error	Z-Value	**P>z**	95% Confidence interval	
Business age	-.0612727	.0091332	-6.71	**0.000**	-.0791736	-.0433719
Number of employees	.2853248	.0978236	2.92	**0.004**	.0935941	.4770555
Tax	-.0009772	.0014942	-0.65	**0.513**	-.0039057	.0019513
ICT firm density	4.74725	29.86435	0.16	**0.874**	-53.7858	63.2803
Export ratio	.299856	.1128885	2.66	**0.008**	.0785987	.5211134
/cut1	-1.990504	.665925			-3.295693	-.685315
/cut2	-.9320508	.6548006			-2.215436	.3513348
/cut3	-.3936059	.6507779			-1.669107	.8818954
/cut4	.156512	.6505227			-1.118489	1.431513

Ordered Probit Regression Model 9		Number of observations:175			Pseudo R2 = 0.1030	
LR chi2(5) = 56.66		Prob > chi2 = 0.0000			Log likelihood = -246.68022	
Sales growth	Coefficient	Standard error	Z-Value	**P>z**	95% Confidence interval	
Business age	-.0622626	.0094996	-6.55	**0.000**	-.0808814	-.0451887
Number of employees	.2909025	.1016746	2.86	**0.004**	.0916239	.5185074
Tax	-.0003757	.00152	-0.25	**0.805**	-.0033549	.002024
Regional policy	-.0793588	.1030412	-0.77	**0.441**	-.2813159	.3322709
Export ratio	.2742637	.1155354	2.37	**0.018**	.0478186	.5078595
/cut1	-1.839102	.6901531			-3.191777	-.4864263
/cut2	-.7752586	.6812694			-2.110522	.5600049
/cut3	-.241249	.6778219			-1.569756	1.087258
/cut4	.2922003	.6770623			-1.034817	1.619218
Ordered Probit Regression Model 10		Number of observations:160			Pseudo R2 = 0.1408	
LR chi2(5) = 71.41		Prob > chi2 = 0.0000			Log likelihood = -217.88332	
Sales growth	Coefficient	Standard error	Z-Value	**P>z**	95% Confidence interval	
Business age	-.0739443	.0107636	-6.87	**0.000**	-.0950405	-.0528481
Number of employees	.4255806	.1111843	3.83	**0.000**	.2076634	.6434978
Tax	-.0019861	.0016291	-1.22	**0.223**	-.0051792	.0012069
Equity ratio	.2604528	.1027162	2.54	**0.011**	.0591328	.4617728
Export ratio	.3042691	.1204765	2.53	**0.012**	.0681395	.5403986
/cut1	-2.341395	.7328978			-3.777848	-.9049413
/cut2	-1.270609	.7198295			-2.681448	.1402312
/cut3	-.6607789	.7153015			-2.062744	.7411862
/cut4	-.0072122	.7137889			-1.406213	1.391788
Ordered Probit Regression Model 11		Number of observations:186			Pseudo R2 = 0.1136	
LR chi2(5) = 66.50		Prob > chi2 = 0.0000			Log likelihood = -259.50883	
Sales growth	Coefficient	Standard error	Z-Value	**P>z**	95% Confidence interval	
Business age	-.0563961	.0093217	-6.05	**0.000**	-.0746664	-.0381258
Number of employees	.2568207	.0985279	2.61	**0.009**	.0637096	.4499317
Tax	-.0011859	.0014761	-0.80	**0.422**	-.004079	.0017071
VC	.6267491	.2492107	2.51	**0.012**	.1383052	1.115193
Export ratio	.2554976	.1144972	2.23	**0.026**	.0310873	.479908
/cut1	-2.03101	.6648558			-3.334103	-.7279165
/cut2	-.9740744	.6539016			-2.255698	.3075491
/cut3	-.4264336	.6497981			-1.700014	.8471472
/cut4	.1442275	.649489			-1.128747	1.417202

Appendix to Chapter 3

Table A.3.1 Classification of (OECD) ICT Sector

IPC 4 classes
'B07C','B41J','B41K','G01B','G01C','G01D','G01F','G01G','G01H','G01J','G01K','G01L','G01M','G01N','G01P','G01R','G01S','G01V','G01W','G02F','G03G','G05B','G05F','G08C','G08G','G09B','G09C','G09G','G10L','G11B','G11C','H01L','H01P','H01Q','H03B','H03C','H03D','H03F','H03G','H03H','H03J','H03K','H03L','H03M','H04B','H04H','H04J','H04K','H04L','H04M','H04N','H04Q','H04R','H04S','H1S5','H1'
IPC 8 classes
'G02B 6','H01B 11','H01J 11','H01J 13','H01J 15','H01J 17','H01J 19','H01J 21','H01J 23','H01J 25','H01J 27','H01J 29','H01J 31','H01J 33','H01J 40','H01J 41','H01J 43','H01J 45','H01S 3/025','H01S 3/043','H01S 3/063','H01S 3/067','H01S 3/085','H01S 3/0933','H01S 3/0941','H01S 3/103','H01S 3/133','H01S 3/18','H01S 3/19','H01S 3/25'
Large IPC4 classes
'G06/G07

Table A.3.2 Cooperation Networks with at Least one Cooperation Partner (Applicant) Headquartered outside of the Region under Consideration

NUTS-2 region of Cologne for the period of	**1984-1993**	**1994-2003**
Number of all weighted ICT patent applications	643	1993
Number of applicants with at least one cooperation partner (applicant) headquartered outside of the region under consideration > 1 per patent (modes)	56	136
Ratio of applicants > 1 per patent (cooperations)	8.71%	6.82%
Network Density	0.0416	0.0150
Network Degree-centrality C_D	6.88%	5.95%
Network Betweenness Centrality C_B	0.73%	0.96%
Average Ties per Actor	2.286	2.029
Inclusion of Research Institutes	Yes	Yes

Most Central Applicants/$C_D(i)$ in %
(Degree-Centrality)%

1984-1993	**1994-2003**
Vaillant Ltd./10.909	ROBERT BOSCH GMBH/7.407
VAILLANT Ges.m.b.H/10.909	Koninklijke Philips Electronics N.V./6.667
Vaillant s.a./10.909	Daimler AG/6.667
Joh. Vaillant GmbH u. Co./10.909	Philips Intellectual Property & Standards GmbH/5.926
VAILLANT p.A.R.L/10.909.	Decomsys - Dependable Computer Systems,
Vaillant GmbH/ 10.909	Hardware and Software Entwicklung GmbH/5.185
SCHONEWELLE B.V./10.909	Bayerische Motorenwerke AG/5.185
FORD-WERKE AKTIENGESELL-SCHAFT/9.091	Freescale Semiconductor, Inc./5.185
Seidenberg, Jürgen, Dr./5.455	GENERAL MOTORS CORPORATION/3.704
Blazek, Vladimir, Dr.-Ing./5.455	Bayer MaterialScience AG/3.704
Ford Motor Company Limited/5.455	Deutsche Telekom AG/3.704
FORD MOTOR COMPANY/5.455	Forschungszentrum Jülich GmbH/3.704
Philips Corporate Intellectual Property GmbH/5.455	Sony Corporation/2.963
Forschungszentrum Jülich GmbH/5.455	
FORD FRANCE p.A./5.455	

Most Central Applicants/$C_B(i)$ in %
(Betweenness-Centrality)

1984-1993	**1994-2003**
FORD-WERKE AKTIENGESELL-SCHAFT/0.741	ROBERT BOSCH GMBH/0.984
SIEMENS AKTIENGESELLSCHAFT/0.337	Daimler AG/0.829
Forschungszentrum Jülich GmbH/ 0.202	Forschungszentrum Jülich GmbH/0.586
Saint-Gobain Vitrage/0.067	Deutsche Telekom AG/0.586
	Koninklijke Philips Electronics N.V./0.287
	Bayer MaterialScience AG/0.133
	Philips Intellectual Property & Standards GmbH/0.094
	Bayer Aktiengesellschaft/0.066
	Sony Corporation/0.066
	Agfa NDT GmbH/0.022
	T-Mobile Germany GmbH/0.011
	SAINT-GOBAIN GLASS FRANCE/0.011
	KRAUTKRÄMER GmbH & Co./0.011

Source: Own Calculation

Figure A.3.1 Cologne (NUTS-2) with at Least one Cooperation Partner (Applicant) Headquartered outside of the Region for the Period of 1984-1993 (t_0)

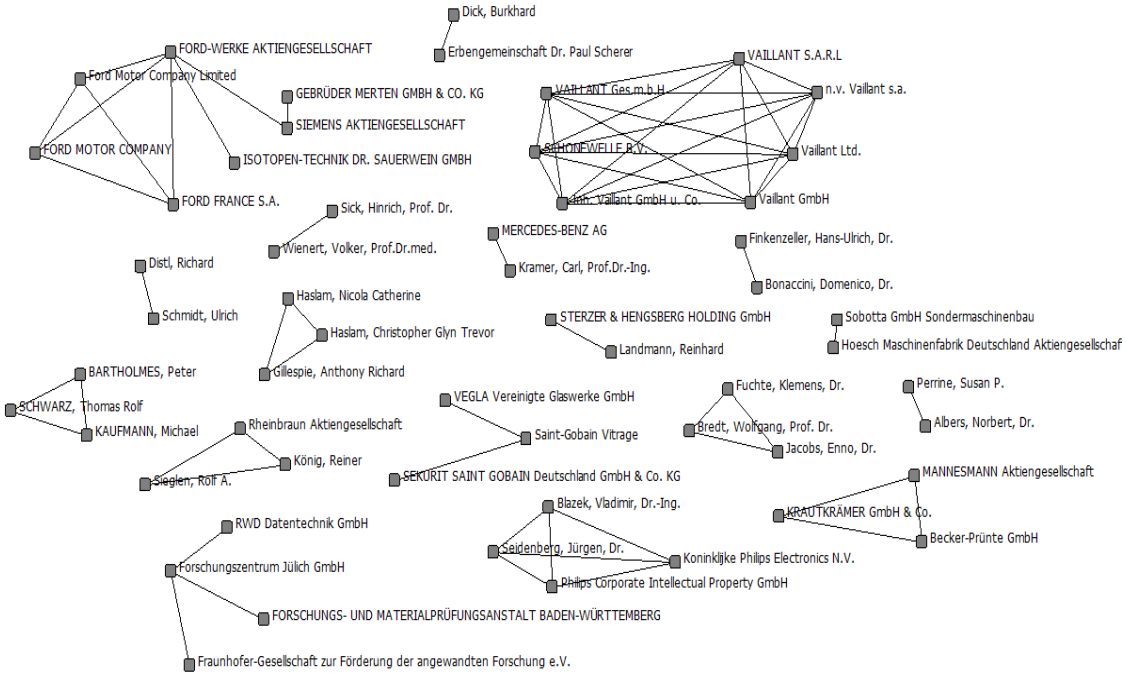


Figure A.3.2 Cologne (NUTS-2) with at Least one Cooperation Partner (Applicant) Headquartered outside of the Region for the Period of 1994-2003 (t_1)

Source: Own Illustration

Table A.3.3 Cooperation Networks with at Least One Cooperation Partner (Applicant) Headquartered outside of the Region under Consideration

NUTS-2 region of Karlsruhe for the period of	**1988-1997**	**1998-2007**
Number of all weighted ICT patent applications:	1273	2103
Number of applicants with at least one cooperation partner (applicant) headquartered outside of the region under consideration	69	104
Ratio of applicants > 1 per patent (cooperations)	5.42%	4.95%
Network Density	0.0367	0.0207
Network Degree-centrality C_D	6.73%	5.75%
Network Betweenness Centrality C_B	0.78%	2.65%
Average Ties per Actor	2.493	2.135
Inclusion of Research Institutes	Yes	Yes

Most Central Applicants/C_D(i) in %
(Degree-Centrality)%

1988-1997	**1998-2007**
Seeger, Stefan, Dr./10.294	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V./7.767
Seidel, Claus/10.294	Roche Diagniostics GMBH/7.767
Köllner, Malte/10.294	BASF AG/7.796
DREXHAGE, Karl-Heinz, Prof. Dr./10.294	Forschungszentrum Karlsruhe GmbH/6.796
Sauer, Markus/10.294	Europäisches Laboratorium für Molekularbiologie/5.825
Schulz, Andreas/10.294	Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V./4.854
Wolfrum, Jürgen, Prof. Dr./10.294	Bruyns, Eddy/4.854
Han, Kyung-Tae/10.294	Deutsches Krebsforschungszentrum/4.854
KERNFORSCHUNGSZENTRUM KARLSRUHE GMBH/7.353	Schraven, Burkhart/4.854
Forschungszentrum Karlsruhe GmbH7.353	Marie-Cardine, Anne/4.854
Leroy, Marie-Hélène/5.882	Kirchgessner, Henning/4.854
Abbas, Kamel/5.882	Meuer, Stefan/4.854
Zerari, Amyn/5.882	Essenpreis, Matthias/3.883
Abbas, Said/5.882	Boecker, Dirk/3.883
Dubois, Clément/5.882	Nickell, Stephan/3.883
	F. Hoffmann - La Roche AG/3.883

Most Central Applicants/C_B(i) in %
(Betweenness-Centrality)

1988-1997	**1998-2007**
Forschungszentrum Karlsruhe GmbH/0.790	BASF AG/2.722
KERNFORSCHUNGSZENTRUM KARLSRUHE GMBH/0.790	Deutsches Krebsforschungszentrum/2.322
Roche Diagnostics GmbH/0.132	Forschungszentrum Karlsruhe GmbH/1.980
Deutsches Krebsforschungszentrum/0.044	Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V./1.371
	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V./0.733
	Roche Diagniostics GMBH/0.457
	Europäisches Laboratorium für Molekularbiologie/0.209
	SAP AG/0.209
	F. Hoffmann - La Roche AG/0.105
	Wolfrum, Jürgen, Prof. Dr./0.038

Source: Own Calculation

Figure A.3.3 Karlsruhe (NUTS-2) with at Least one Cooperation Partner (Applicant) Headquartered outside of the Region for the Period of 1988-1997 (t_0)

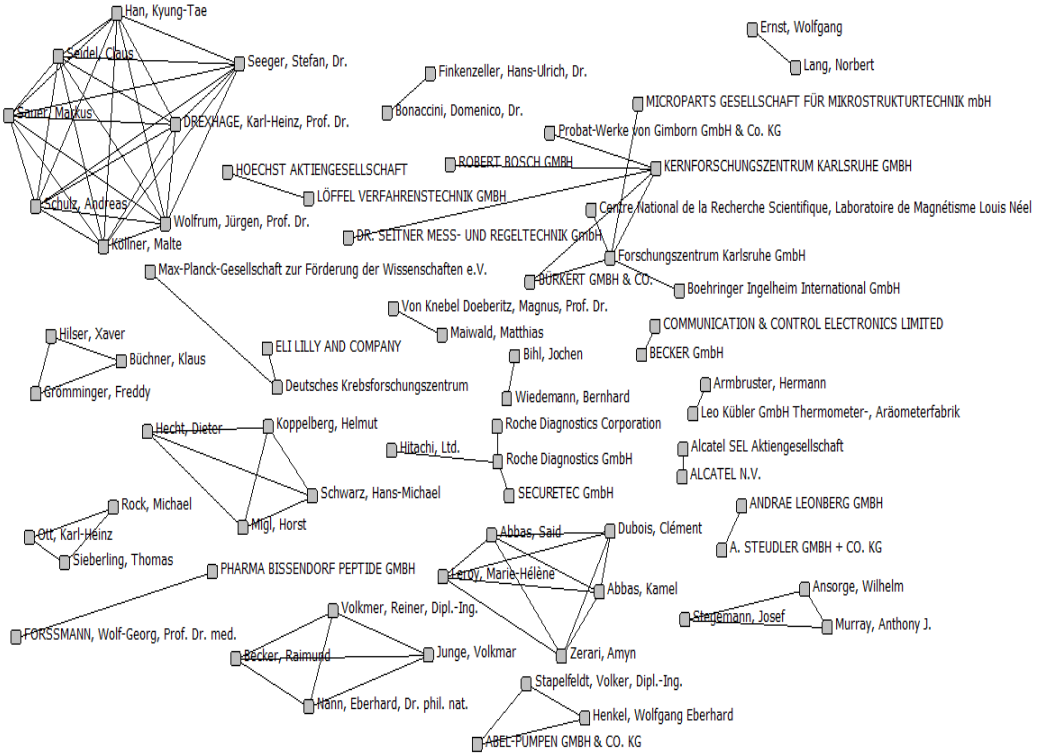


Figure A.3.4 Karlsruhe (NUTS-2) with at Least one Cooperation Partner (Applicant) Headquartered outside of the Region for the Period of 1998-2007 (t_1)

Source: Own Illustration

Table A.3.4 Cooperation Networks in which all Cooperation Partners (Applicants) are Headquartered outside of the Region under Consideration

NUTS-2 region of Cologne for the period of	**1984-1993**	**1994-2003**
Number of all weighted ICT patent applications:	643	1993
Number of applicants in which all cooperation partners (applicants) are headquartered outside of the region under consideration	26	75
Ratio of applicants > 1 per patent (cooperations)	4.04%	3.76%
Network Density	0.1569	0.0418
Network Degree-centrality C_D	21.12%	20.42%
Network Betweenness Centrality C_B	0.28%	2.94%
Average Ties per Actor	3.923	3.093
Inclusion of Research Institutes	Yes	Yes

Most Central Applicants/$C_D(i)$ in %
(Degree-Centrality)%

1984-1993	**1994-2003**
Joh. Vaillant GmbH u. Co./36.000	Philips Intellectual Property & Standards GmbH/24.324
VAILLANT Ges.m.b.H/36.000	Koninklijke Philips Electronics N.V./22.973
Vaillant GmbH/36.000	Volkswagen AG/14.865
Vaillant Ltd./36.000	MOTOROLA, INC./13.514
n.v. Vaillant s.a./36.000	Daimler AG/13.514
VAILLANT p.A.R.L/36.000	NXP B.V./13.514
COFRABEL N.V./32.000	ROBERT BOSCH GMBH/13.514
SCHONEWELLE B.V./32.000	Freescale Semiconductor, Inc./13.514
Vaillant-Schonewelle B.V./32.000	Bayerische Motoren Werke Aktiengesellschaft/13.514
Vaillant B.V./24.000	GENERAL MOTORS CORPORATION/13.514
Koninklijke Philips Electronics N.V./8.000	BMW AG/13.514
SIEMENS AKTIENGESELLSCHAFT/8.000	Vaillant GmbH/6.757
	Vaillant B.V./6.757
	Vaillant A/S/6.757
	Vaillant Ltd./6.757
	VAILLANT p.A.R.L/6.757
	Vaillant N.V./6.757

Most Central Applicants/$C_B(i)$ in %
(Betweenness-Centrality)

1984-1993	**1994-2003**
SIEMENS AKTIENGESELLSCHAFT/0.333	Philips Intellectual Property & Standards GmbH/2.999
Koninklijke Philips Electronics N.V./0.333	Koninklijke Philips Electronics N.V./2.258
Joh. Vaillant GmbH u. Co./0.167	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V./1.444
Vaillant Ltd./0.167	Volkswagen AG/0.740
VAILLANT Ges.m.b.H/0.167	Sony Germany GmbH/0.074
VAILLANT p.A.R.L/0.167	AUDI AG/0.037
Vaillant GmbH/0.167	CENTRE NATIONAL DE LA RECHERCHE
n.v. Vaillant s.a./0.167	Messer Group GmbH/0.037
SCIENTIFIQUE (CNRS)/0.037	

Source: Own Calculation

Figure A.3.5 All Applicants outside of Cologne (NUTS-2) for the Period of 1984-1993 (t_0)

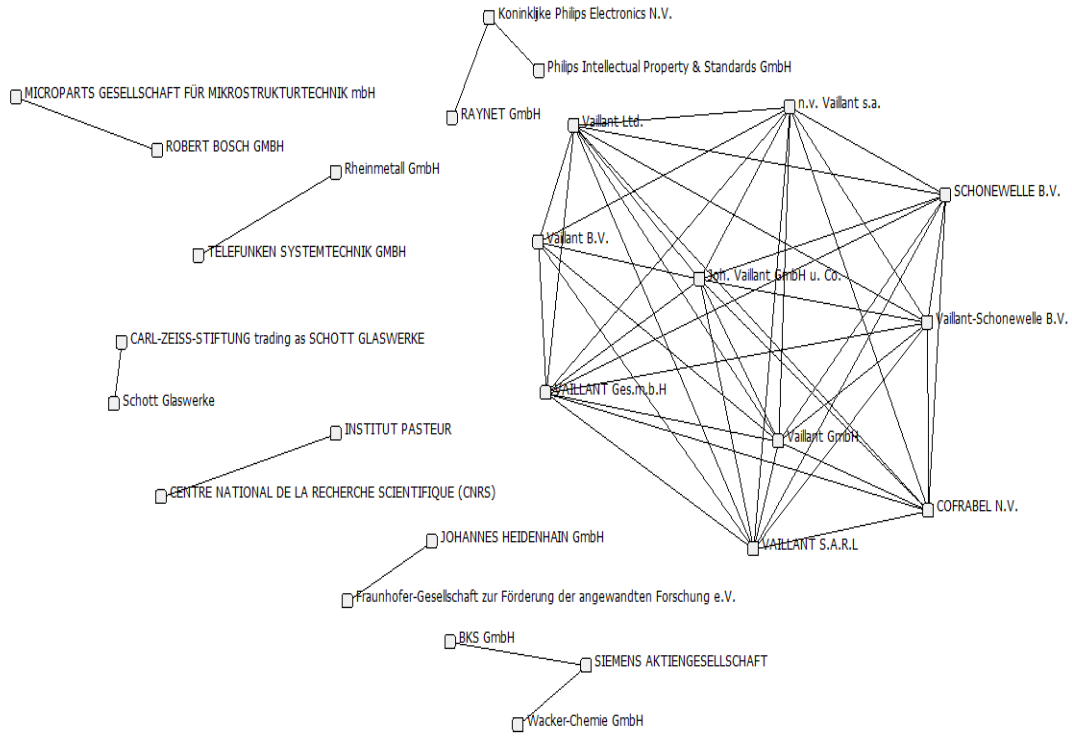
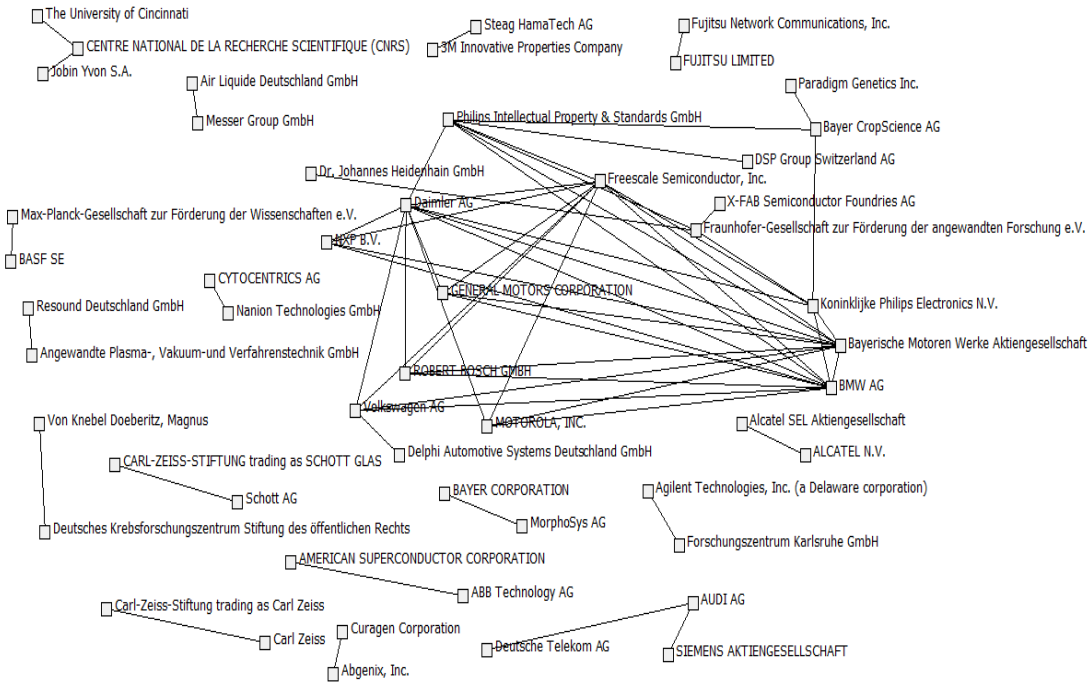


Figure A.3.6 All Applicants outside of Cologne (NUTS-2) for the Period of 1994-2003 (t_1)



Source: Own Illustration

Table A.3.5 Cooperation Networks in which all Cooperation Partners (Applicants) are Headquartered outside of the Region under Consideration

NUTS-2 region of Karlsruhe for the period of	**1988-1997**	**1998-2007**
Number of all weighted ICT patent applications:	1273	2103
Number of applicants in which all cooperation partners (applicants) are headquartered outside of the region under consideration	69	91
Ratio of applicants > 1 per patent (cooperations)	5.42%	4.33%
Network Density	0.0332	0.0252
Network Degree-centrality C_D	11.55%	10.94%
Network Betweenness Centrality C_B	4.34%	1.62%
Average Ties per Actor	2.261	2.264
Inclusion of Research Institutes	Yes	Yes

Most Central Applicants/C_D(i) in %
(Degree-Centrality)%

1988-1997	**1998-2007**
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V./14.706	ROBERT BOSCH GMBH/13.333
Alcatel SEL Aktiengesellschaft/13.235	Volkswagen AG/12.222
SIEMENS AKTIENGESELLSCHAFT/10.294	Daimler AG/10.000
ANT Nachrichtentechnik GmbH/10.294	BMW AG/10.000
KRONE Aktiengesellschaft/10.294	Koninklijke Philips Electronics N.V./10.000
Koninklijke Philips Electronics N.V./10.294	Bayerische Motoren Werke Aktiengesellschaft/10.000
Quante Aktiengesellschaft/10.294	MOTOROLA, INC./10.000
Daimler-Benz AG/10.294	GENERAL MOTORS CORPORATION/10.000
Philips Corporate Intellectual Property GmbH/10.294	Freescale Semiconductor, Inc./10.000
Ericsson FUBA Telecom GmbH/10.294	Philips Intellectual Property & Standards GmbH/10.000
Volkswagen AG/5.882	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V./6.667
Vantico AG/5.882	BASF AG/4.444
ATOTECH Germany GmbH/5.882	
Dyconex AG/5.882	
Technische Universität Dresden/5.882	

Most Central Applicants/C_B(i) in %
(Betweenness-Centrality)

1988-1997	**1998-2007**
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V./4.434	ROBERT BOSCH GMBH/1.648
Volkswagen AG/3.073	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V./1.124
Daimler-Benz AG/2.546	Volkswagen AG/0.774
Alcatel SEL Aktiengesellschaft/0.658	BASF AG/0.225
ROBERT BOSCH GMBH/0.044	Lucent Technologies Inc./0.100
	International Business Machines Corporation/0.050
	Forschungszentrum Jülich GmbH/0.025
	SIEMENS AKTIENGESELLSCHAFT/0.025
	GeoForschungsZentrum Potsdam /0.025

Source: Own Calculation

Figure A.3.7 All Applicants outside of Karlsruhe (NUTS-2) for the Period of 1988-1997 (t_0)

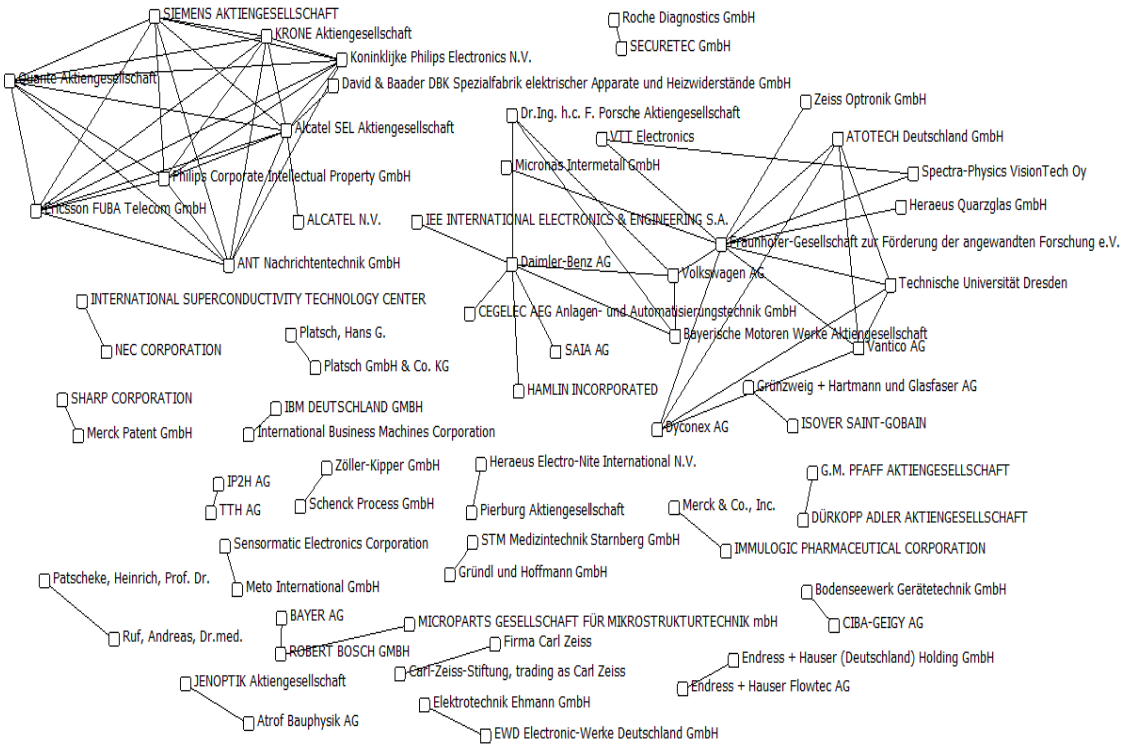
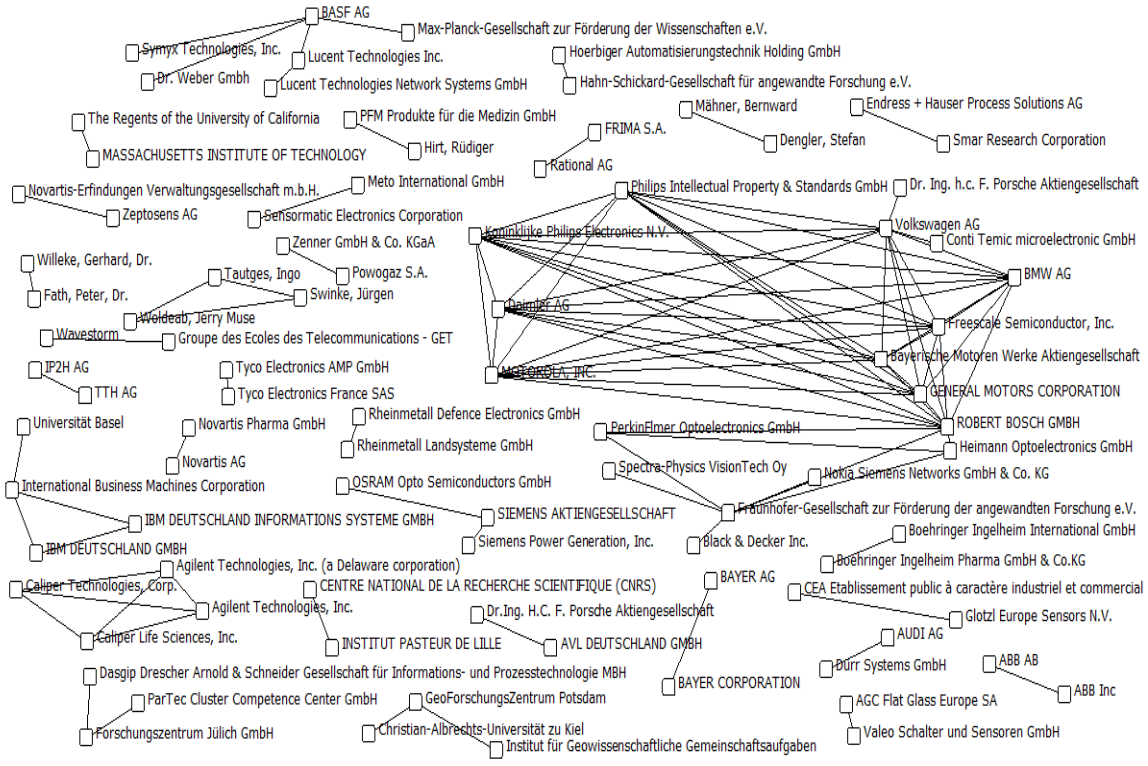


Figure A.3.8 All Applicants outside of Karlsruhe (NUTS-2) for the Period of 1998-2007 (t_1)



Source: Own Illustration

Table A.3.6 Cooperation Networks in which all Cooperation Partners (Applicants) are Headquartered inside the Region under Consideration

NUTS-2 region of Cologne for the period of	**1984-1993**	**1994-2003**
Number of all weighted ICT patent applications:	643	1993
Number of applicants in which all cooperation partners (applicants) are headquartered inside the region under consideration	24	36
Ratio of applicants > 1 per patent (cooperations)	3.73%	1.81%
Network Density	0.0688	0.0333
Network Degree-centrality C_D	6.43%	2.45%
Network Betweenness Centrality C_B	0%	0.17%
Average Ties per Actor	1.583	1.167
Inclusion of Research Institutes	Yes	Yes

Most Central Applicants/C_D(i) in %
(Degree-Centrality)%

1984-1993	**1994-2003**
Scherer, Gertrud/13.043	Kollberg, Klaus/5.714
Scherer, Karl Joachim Dietmar/13.043	Alléra, Axel/5.714
Scherer, Peter (represented by Scherer, Gertrud)/13.043	Bayer MaterialScience AG/5.714
Scherer, Andreas/13.043	Daufeldt, Dr., Sabine/5.714
Engelhardt, Harald, Dipl.-Ing./8.696	Daufeldt, Hans-Peter/5.714
Reul, Helmut, Prof. Dr./8.696	Schiessl, Peter/5.714
Graab, Helmut/8.696	Raupach, Michael/5.714
Martin, Claus/8.696	
Rau, Günter, Prof. Dr./8.696	
Esser, Reinhard/8.696	

Most Central Applicants/C_B(i) in %
(Betweenness-Centrality)

1984-1993	**1994-2003**
	Bayer MaterialScience AG/0.168

Source: Own Calculation

Figure A.3.9 All Applicants within Cologne (NUTS-2) for the Period of 1984-1993 (t_0)

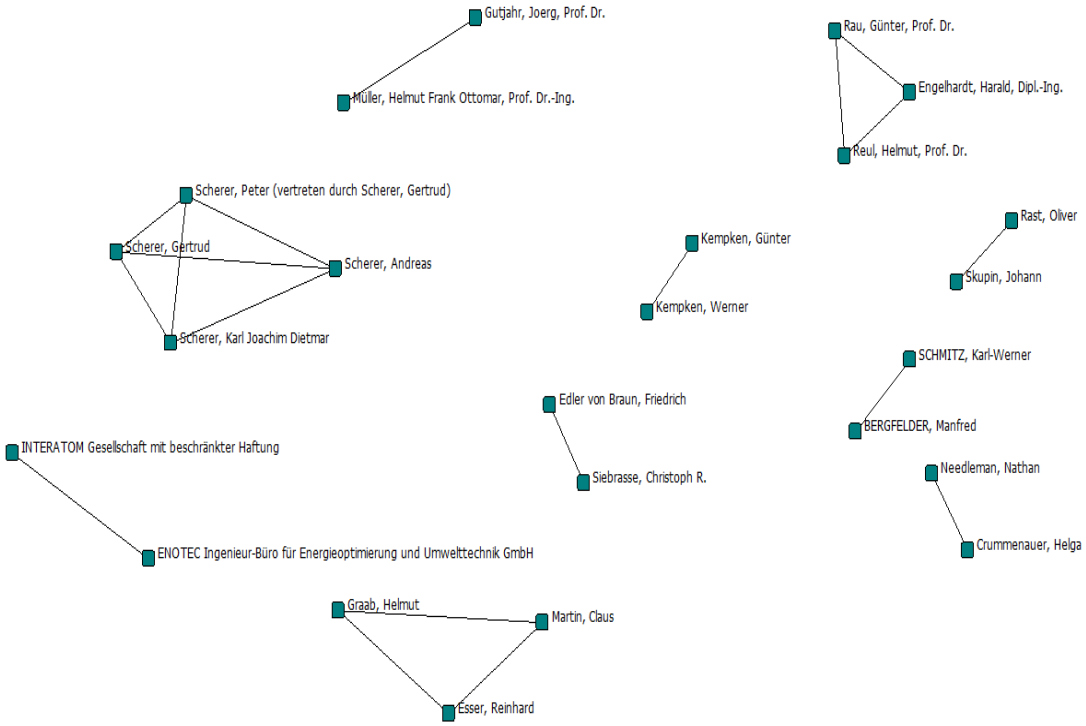
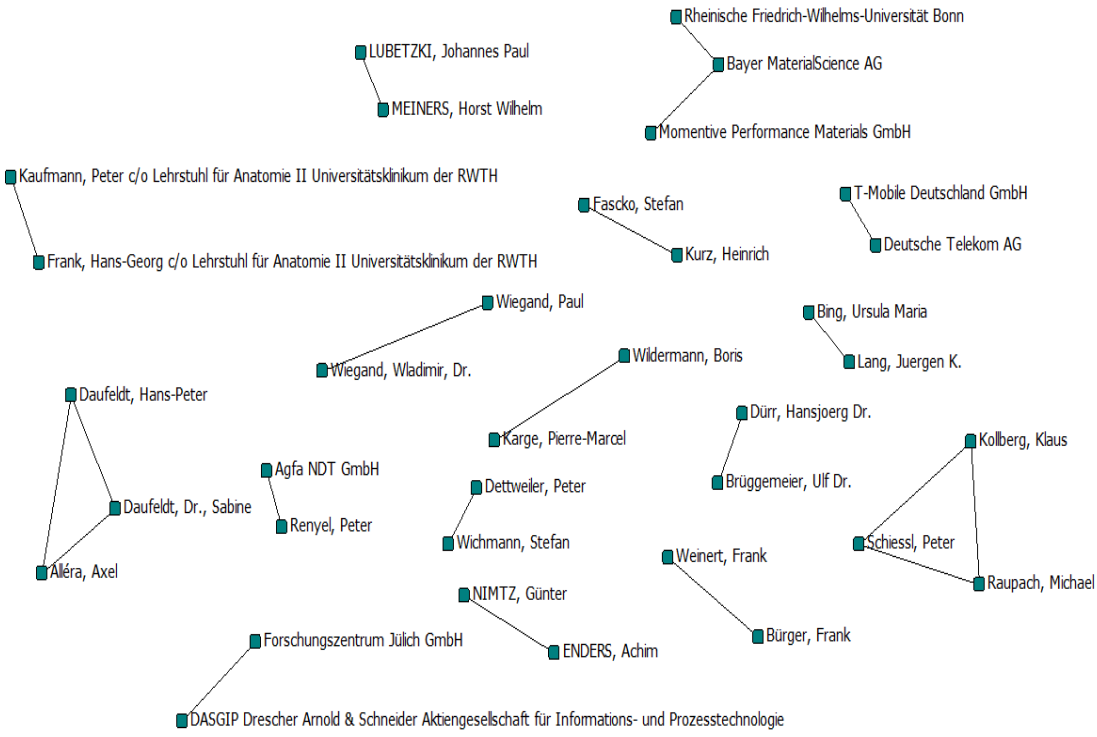


Figure A.3.10 All Applicants within Cologne (NUTS-2) for the Period of 1994-2003 (t_1)



Source: Own Illustration

Table A.3.7 Cooperation Networks in which all Cooperation Partners (Applicants) are Headquartered inside the Region under Consideration

NUTS-2 region of Karlsruhe for the period of	**1988-1997**	**1998-2007**
Number of all weighted ICT patent applications:	1273	2103
Number of applicants in which all cooperation partners (applicants) are headquartered inside the region under consideration	30	38
Ratio of applicants > 1 per patent (cooperations)	2.36%	1.81%
Network Density	0.0713	0.0341
Network Degree-centrality C_D	10.46%	4.82%
Network Betweenness Centrality C_B	2.17%	0.45%
Average Ties per Actor	2.067	1.263
Inclusion of Research Institutes	Yes	Yes

Most Central Applicants/C_D(i) in %
(Degree-Centrality)%

1988-1997	**1998-2007**
Forschungszentrum Karlsruhe GmbH/17.241	Schuster, Ralf/8.108
Harman Becker Automotive Systems GmbH/13.793	Siegrist, Alexandra/8.108
BECKER GmbH/13.793	Baréz, Klaus/8.108
OASIS SiliconSystems Holding AG/13.793	Deutsches Krebsforschungszentrum/8.108
SMSC Europe GmbH/13.793	Siegrist, Michael/8.108
Silicon Systems GmbH Multimedia Engineering/13.793	
KERNFORSCHUNGSZENTRUM KARLSRUHE GMBH/13.793	
UNIVERSITÄT KARLSRUHE (TECHNISCHE HOCHSCHULE)/10.345	
Deutsches Krebsforschungszentrum/10.345	
Lux, Benjamin Wolfgang/6.897	
Lux, Viola Irmgard/6.897	
Burckhardt, Jean, Dr./6.897	
Seelig, Hans Peter, Prof. Dr./6.897	
Seelig, Renate, Dr./6.897	
Lux, Jasmin Sabrina/6.897	

Most Central Applicants/C_B(i) in %
(Betweenness-Centrality)

1988-1997	**1998-2007**
Forschungszentrum Karlsruhe GmbH/2.217	Deutsches Krebsforschungszentrum/0.450
KERNFORSCHUNGSZENTRUM KARLSRUHE GMBH/1.232	

Source: Own Calculation

Figure A.3.11 All Applicants within Karlsruhe (NUTS-2) for the Period of 1988-1997 (t_0)

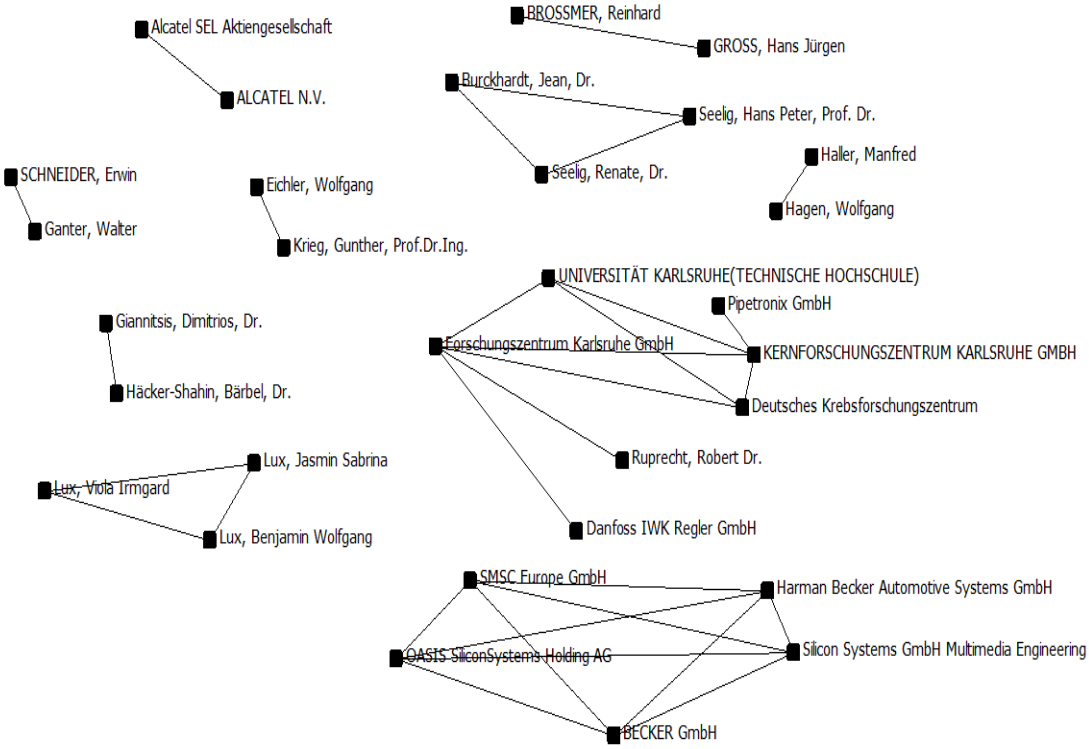
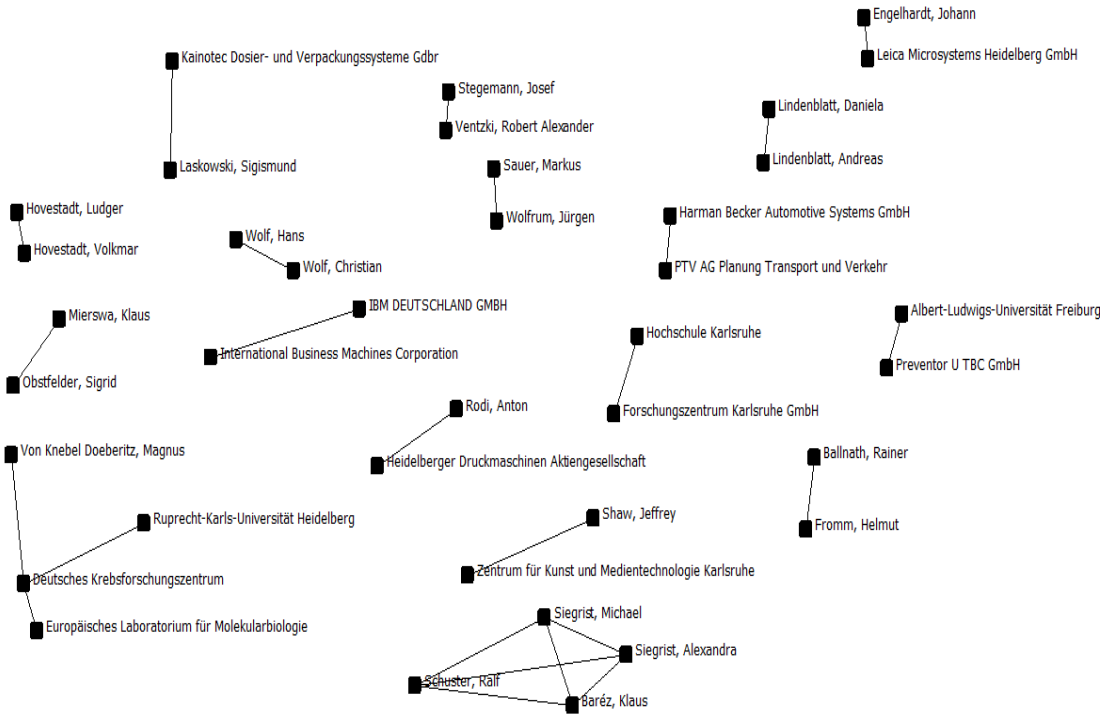


Figure A.3.12 All Applicants within Karlsruhe (NUTS-2) for the Period of 1998-2007 (t_1)



Source: Own Illustration

Appendix to Chapter 4

Table A.4.1 Data Definitions and Sources

Variable	**Description**	**Source**
Early-Stage Venture Capital in % of GDP	Venture capital investment is defined as private equity raised for investment in companies; management buyouts, management buy-ins and venture purchase of quoted shares are excluded. Data are divided into two investment stages: early-stage (seed + start-up) and later-stage (expansion and replacement capital). The data are provided by the European Private Equity and Venture Capital Association (EVCA). The indicators are presented as a percentage of GDP (gross domestic product at market prices), which is defined in conformity with the European System of national and regional accounts in the Community (ESA 95).	Eurostat
Later-Stage Venture Capital in % of GDP		
Research and Development Expenditures (R&D) in % of GDP	Research and experimental development (R&D) comprise creative work undertaken on a systematic basis to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. R&D expenditures include all expenditures for R&D performed within the business enterprise sector (BERD) in the national territory during a given period, regardless of the source of funds. R&D expenditure in BERD is shown as a percentage of GDP (R&D intensity).	Eurostat

Stock Market Capitalization in % of GDP	Market capitalization of listed companies (% of GDP) Market capitalization (also known as market value) is the share price times the number of shares outstanding. Listed domestic companies are the domestically incorporated companies listed on the country's stock exchanges at the end of the year. Listed companies do not include investment companies, mutual funds, or other collective investment vehicles.	World Development Indicators CD 2007
Banking Sector (Loans/GDP)	To measure the weight of the banking sector, I follow the approach of LEVINE/ZERVOS (1998). The variable banking sector equals the value of loans made by banks to private enterprises divided by GDP. Specifically, I divided line 22d by 99b from the IMF´s International Financial Statistics	International Financial Statistics from the International Monetary Fund (Yearbook 2006)
Corporate Tax Rate in %	The basic combined central and sub-central (statutory) corporate income tax rate given by the adjusted central government rate plus the sub-central rate.	OECD Tax Database
Gross Domestic Product Growth (GDPgrowth) in %	GDP growth (annual %) Annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2000 U.S. dollars. GDP is the sum of the gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. GDP is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources.	World Development Indicators CD 2007
High-tech Patent Applications to the EPO per Million Inhabitants	The data refers to the ratio of patent applications made directly to the European Patent Office (EPO) or via the Patent Cooperation Treaty and designating the EPO (Euro-PCT), in the field of high-technology patents per million inhabitants of a country. The definition of high-technology patents uses specific subclasses of the International Patent Classification (IPC) as defined in the	Eurostat

	trilateral statistical report of the EPO, JPO and USPTO.	
Annual Unit Labor Costs (Business Sector excl. Agriculture)	Annual unit labor costs (ULCs) are calculated as the quotient of total labor costs and real output. For more information on the OECD System of Unit Labor Cost, see http://stats.oecd.org/mei/	OECD Statistics
Self-Employment Rates as a Percentage of Total Civilian Employment	Self-employment jobs are those jobs in which the remuneration is directly dependent upon the profits (or the potential for profits) derived from the goods or services produced (where own consumption is considered to be part of profits). The incumbents make the operational decisions affecting the enterprise or delegate such decisions while retaining responsibility for the welfare of the enterprise. In this context, "enterprise" includes one-person operations.	OECD Factbook 2009: Economic, Environmental and Social Statis-tics
Interest Rates in %	The yield of long term (in most cases 10 year) government bonds are used as the representative 'interest rate' for each country. Generally, the yield is calculated at the pre-tax level before deductions for brokerage costs and commissions and is derived from the relationship between the present market value of the bond and the value at maturity, also taking into account interest payments paid through maturity.	OECD Statistics
Strictness of Employment Protection (Regular Employment)	The OECD indicators of employment protection measure the procedures and costs involved in dismissing individuals or groups of workers and the procedures involved in hiring workers on fixed-term or temporary work agency contracts.	OECD Statistics