Geographical Business Clusters

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Concepts for Cluster-Identification with an Application to an Alleged Aeronautics Cluster in Northern Germany

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Preface

This dissertation has been an academic spin-off of a joint consultancy project with Prof. Dr. Wilhelm Pfähler of the Institute of Allocation and Competition, University of Hamburg (Pfähler and Lublinski, 2002). The latter has been conducted for the Economic Ministry of the Free and Hanseatic City of Hamburg, Airbus Deutschland GmbH and Hamburg Airport GmbH. It had the following tasks: First, it aimed at identifying an alleged cluster of aeronautic (supplying) firms in Northern Germany. Second, we set out to describe the alleged cluster along a reasonable set of cluster dimensions. Thirdly, we have analysed which agglomeration forces are operating in the alleged cluster. Fourthly, we have investigated the business environment (market, political, technological, competitive and business restructuring trends) that may affect cluster firms in the future. Lastly, our aim was to provide a long-term vision for the alleged cluster, as well as recommendations for public and firm policy.

The consultancy project and this dissertation, which have been prepared and written simultaneously, have provided grounds for synergy. The consultancy project provided the access to the clients' data bases, especially that of Airbus Deutschland GmbH and Lufthansa Technik AG, and the financial funding for the surveying of firms by telephone as well as the installation of the data bases. The preparation of this dissertation has provided some of the conceptual prerequisites for the consultancy project. This includes two aspects: First, the clarification and appreciation of technical terminology and methodology, of which some considerations on Input Output methods have been published in Pfähler (ed.) (2001), and second, the development of a careful empirical approach for cluster identification, which comprises a technique for the detection of the various agglomeration forces operating within a specific cluster. The latter has been developed partly in cooperation with Dr. Werner Bönte, Institute of Allocation and Competition, University of Hamburg. Specifically, the econometric analysis has been a product of joint efforts (see section 3.3). The development of this technique has resulted in two papers: Lublinski (2002) as well as Bönte and Lublinski (2002). They have been presented at the winter seminar of the Regional Science Association (German speaking group: Gesellschaft für Regionalforschung), Hermagor, Feb. 2002, and at the High Technology Small Firms One Day Cluster Conference, Manchester Business School, April 2002, respectively.

From a PhD student's point of view the simultaneous nature of this research project has been particularly helpful, because great learning effects stem from the composition of our team of three. Specifically, the author of this dissertation has greatly benefitted from a highly competent empirical researcher, Dr. Werner Bönte, as well as from the wisdom of a 'senior', namely that of Prof. Dr. Wilhelm Pfähler.

Hamburg, June 2002 Alf Erko Lublinski

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1. Introduction

Recent years have seen a great interest in the phenomenon of geographical business clusters and in the dynamic processes generating clusters. As global competition intensifies we can observe that the prevalent international distribution of firms‘ locations is shaken up. Firms are induced to reconsider their location decisions and regional planners try to attract and *lock-in* (Arthur, 1990) a large share of economic activities that match a pre-existing critical mass of local firms.

In a globalized world where distance seems to be no longer an obstacle, as capital, knowledge, and other resources travel almost freely and at high speed, we would expect economic activity to spread over space. Interestingly, however, we observe a tendency for the geographical concentration of many economic activities. Striking examples of spatial agglomerations of economic activities are Silicon Valley, Route 128, Wall Street and Hollywood, each of which are being associated with specific industries. In Germany the city of Solingen is known for a large number of cutlery producing enterprises, while a large share of Germany's automobile (supplying) industry is centred in Baden-Württemberg and Bavaria. And numerous more examples can be found in this and other countries.[1]

The deeper point to this so-called location paradox lies, of course, in the fact that competitive advantage can indeed be localised (Enright, 2000). It is argued that proximity may generate advantages that spring from regular face-to-face contacts which are more easily realised between nearby agents. According to Marshall (1920) these are advantages of specialised labor pools, intermediate goods and the presence of knowledge spillovers. While some believe that these market and non-market externalities endogenously raise cluster firms‘ performance (Porter, 1998), others doubt that this idea has yet been rigorously tested and evaluated.[2]

The presumption that regional planners have – in principle – effective tools to support cluster development is predicated on some knowledge about what clusters exactly are, how to identify a specific cluster and how to measure their agglomeration externalities that may

[1] Enright, M. (2000), p. 305.
[2] Martin, R. (2002), p. 11.

indicate a justification for public intervention. Unfortunately, scientific literatures do not provide clear-cut answers.

Regional and urban economists have provided theoretical analysis of industrial location choice (see Stahl (1987), Beckman and Thisse (1986) as well as Anas et al. (1998) for reviews). Moreover, the literature in industrial organisation as well as international trade have contributed to a better understanding of the mechanisms that foster clustering, foremost by Porter (1990) as well as Krugman (1991) and Fujita, Krugman and Venables (1999), respectively. Krugman developes a theory to show that regional specialization of industrial activities may be driven by the three Marshallian forces, while Porter stresses the effect of local competition.

However, the cluster phenomenon and, specifically, the microfoundations of its underlying agglomeration forces have not yet been explored to our satisfaction. Anas et al. (1998) conclude their literature review by saying: "*On the theoretical side, we do not know the scale at which the various forces work or what kinds of equilibria the simultaneous interaction of many forces will produce; nor do we have reliable models of dynamic growth paths with random shocks. [...] On the empirical side, despite the increasing sophistication of studies relating a firm's productivity to the size and industrial composition of a city in which it is located, we do not really know the specific forces that produce these relationships, nor just how they depend on industry mix, industrial policy, local public goods, or zoning*".[3]

In this dissertation we will focus on the empirical literature that is relevant to cluster identification. Unfortunately, we observe some confusion with respect to three issues. Firstly, it is unclear how clusters should be defined. Secondly, no standard method of cluster identification has yet evolved. Thirdly, no attempts to quantify the effects of agglomeration forces within a specific cluster have yet been made.

Getting to grips with these problems, the empirical researcher may begin by *defining clusters*. What is required, is a definition that both precisely mirrors the multidimensional character of the phenomenon and that is sufficiently workable to be taken as a starting point for quantitative analysis. So far the scientific community lacks consensus on what the constituent

[3] Anas et al. (1998), p. 1459.

factors of clusters are (Martin, 2002). In the contrary, it offers a collection of cluster definitions (see Table 2, pager 24). They differ with respect to three major aspects. Firstly, the notion of geographic proximity and hence clusters‘ geographic boundaries are not conformly considered a relevant factor of clusters. Some students in this field of research stress it as an important feature of clusters (Enright, 1996, p. 191; Porter, 1998b, p. 199) while others even refrain from considering it an essential factor (Feser, 1998, p. 26; Roelandt and den Hertog, 1999, p. 9).

Secondly, the relevance of the various possible types of interaction between cluster firms is not conformly defined. Some definitions do not mention any linkages (Enright, 1996, p. 191; Swann and Prevezer, 1998, p. 1), others use a deliberately vague notion of networks, interaction or synergy (Rosenfeld, 1997, p. 4; Roelandt and den Hertog, 1999, p. 9), again others (implicitly) focus on linkages that may generate the three Marshallian forces, however, excluding Porter-type effects such as rivalry or demanding customers among others.

Thirdly, the relevance of cluster firms‘ performance as a constituent factor is unclear. It is an interesting artefact, that though it is claimed that clusters may raise the productivity, innovativeness, profitability of its constituent firms as well as the number of firm births in the region (Porter, 1998b; Baptista and Swann, 1998 among other), hardly any cluster definitions in the literature mention cluster firms‘ (alleged) superior performance - Feser (1998, p. 26) being a mere exception. Even Porter (1998b, p.199) himself does not explicitly mention the performance factor in his cluster definition. However, he implicitely argues that cluster firms are internationally competitive as he identifies clusters - among other analytical steps - by detecting industries that show high levels of industry market shares of world exports using his *cluster chart* technique (Porter, 1990).

However, taken all the constituent aspects of clusters, mentioned by different scholars, together, it is here argued that is helpful to consider two cluster dimensions. Firms in clusters are geographically concentrated and proximate (*geographical dimension*) and are inter-linked by various types of linkage flows that generate agglomeration advantages (*functional dimension*).

Given the vagueness of the cluster notion it is not surprising that no standard empirical method for *cluster identification* as well as for the *measurement of agglomeration forces* within a cluster have yet evolved. The reason for this lack of conformity may be that cluster measurement poses an immense difficulty to the empirical researcher, because clusters do not take on tangible forms. Furthermore, clusters are diverse by nature. No two clusters are identical (see Markusen, 1998, for a typology). And, official statistics do not allow to precisely capture the extent of the phenomenon. They may at best provoke the shapes of clusters to loom murkily out of the mist.

Cluster identification studies have differed in the definition of clusters and they have used selective quantitative methods and data sets, specifically employment and Input Output (I/O) data (see Table 1, page 22). However, two main strands of analysis in this field of cluster identification have evolved. They are characterised by the fact that each strand captures only one of two relevant dimensions of clusters, namely either the aspect of geographic proximity between firms (*geographical dimension*) or the aspect of linkages between cluster firms (*functional dimension*).

One strand of analysis has centred on the use of employment data to measure the degree to which firms are spatially proximate (Krugman, 1991; Ellison and Glaeser, 1997, Bergsman et al. (1972/1975) among other). However, a major problem of these studies is, that the spatial boundaries of clusters are determined exogenously. It is assumed that the geographical scope of clusters is identical with that of political regions. Moreover, they do not provide information about what other nearby firms or industries interact with the spatially concentrated sectors.

Another strand of analysis has attempted to identify clusters by employing (national) Input Output data in order to identify groups of interlinked industries (Feser & Bergman, 2000; Czamanski, 1974; Roepke et al., 1974, Campbell, 1975, Roelandt et al., 1997; Hauknes et al., 1999). Yet results of these studies are not clear as to what degree the identified industry groups are geographically proximate.

Although both aspects should be seen as twins there have been only few exceptions that have attempted to combine them (Czamanski, 1977; Streit, 1969; Richter, 1969). These efforts may – under very restrictive assumptions - suggest the existence of groups of relatively strongly co-located firms in a specific region, which may be interlinked by relevant I/O flows. The results of these studies may indicate potential clusters, however, they can not shed much light on the question whether or not these firm groupings constitute indeed actual clusters, in the sense that agglomeration advantages are being generated and effectively exploited.

Concerning the issue of how to analyse *agglomeration forces* within a specific cluster no method has so far been proposed, let alone agreed upon. The empirical work on the drivers of agglomeration has been dominated by econometric studies. These have either measured the effect of a specific agglomeration advantage or the aggregated effect of all possible centripetal forces (Audretsch and Feldman, 1996; Baptista and Swann, 1998; Beaudry, 2001; Glaeser et al., 1992; Henderson, 1994; Jaffe, 1989a). Only few attempts have so far been made to measure the relative importance of the various agglomerative forces (Dumais, Ellison and Glaeser, 1997; Peri and Cunat, 2001). All of these studies aimed at a more general understanding of agglomeration forces, with their research design spanning a set of sub-national regions, rather than focussing on the forces operating in a specific cluster.

Interestingly, there has not only been hardly any connection between the geographical and the linkage aspect in cluster identification studies. To make things even more complicated, there has been practically no interchange between analysts confined with cluster identification and empirical researchers in the field of agglomeration forces. In none of the contributions of the latter strand of analysis we can find citations to the former research efforts and hardly any vice versa. Obviously, no methodological synthesis has so far been forged out of the various strands of cluster analysis. So a relevant question that immediately arises is how an “ideal” measurement concept would look like that allows to identify a specific cluster.

One important aspect is that it should on the one hand be sensitive to clusters’ specific requirements in order to produce sufficiently detailed results. On the other hand, the method should be applicable to different cases in order to gain comparative results. Unfortunately, there is a trade-off between the specific meaningfulness and the comparability of results. A method that meticulously investigates the features of a single cluster can hardly be applied to different cases. On the contrary, a method applied to different cases, can hardly produce specific results in the individual case.

Although all of the methods that attempt to identify cluster members use rather arbitrary cut-off schemes, they do have the virtue of producing quite comparable results. In the case of I/O analysis, the researcher is put into a position to compare clusters‘ industry mixtures. When employment data is used, results allow to compare the degree to which pairs of industries are systematically co-located (spatial association) or the degree to which industries are spatially concentrated. Ellison and Glaeser (1997) have offered a concentration index that is particularly suitable for international comparisons. Maurel and Sédillot (1999) among other have applied a similar approach to compare the degree to which the same industries are spatially concentrated in France and in the U.S. However, all of these methods are 'top-down' national mapping techniques that lack precision with respect to each individual cluster identified on a sub-national level. One example is that they are deliberately vague concerning the spatial boundaries of the clusters identified, because the latter are implicitly and unrealistically assumed to be identical with the political boundaries of the regions studied.

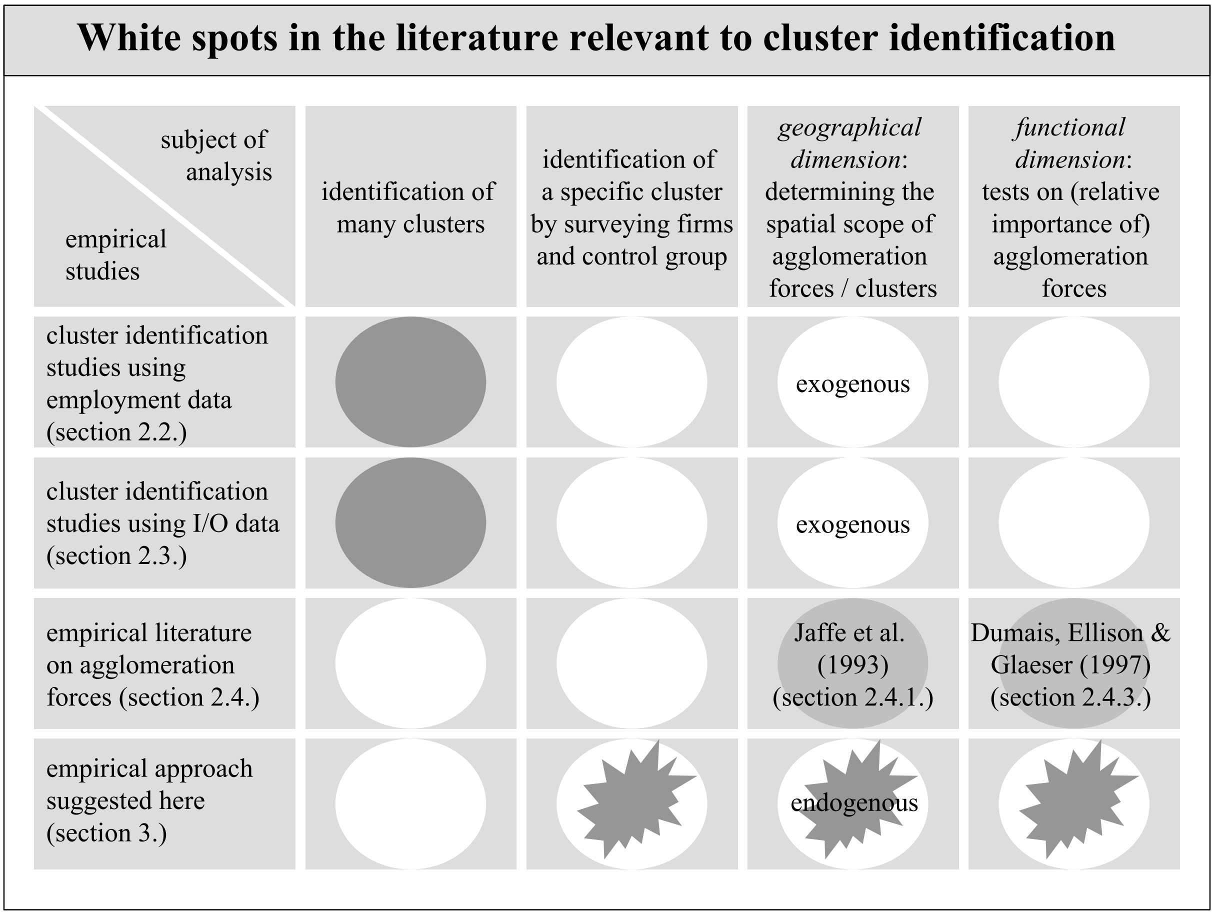
The same critique applies to the efforts made to measure agglomeration forces. The approach chosen by Baptista and Swann (1998), for instance, which has been adopted by others, too, chooses a 'top-down' or 'bird's eye view' on the aggregated effect of agglomeration forces in different industrial groupings. It allows to compare the effect of the degree to which different industries are concentrated across sub-national regions (as measured by own-sector employment) on these firms' innovative performance. Thus, their findings do not take specific characteristics of the various clusters into account. Again, the spatial extent of the clusters is is assumed to be confined to political regions. Moreover, nothing is said about the relative importance of the various externalities within each cluster.

In contrast, 'bottom-up' approaches would allow to identify individual clusters and to measure their agglomeration forces in greater detail and specificity. But most contributions of this type have been qualitative, almost anecdotal-type case studies. They provided deep insights into the history of the clusters studied as well as initial indications of what types of linkages may be important (Saxenian, 1994, Hall and Markusen (eds.), 1985, among other). But these non-quantitative methods are hardly suitable to produce comparable results when applied to different cases.

In a nutshell, there is, firstly, great confusion with respect to what clusters are and how to identify them. Secondly, no quantitative concept has yet been offered to identify a specific cluster. Thirdly, most cluster identification efforts have been rather sloppy in determining the spatial boundaries of a cluster. Fourthly, methodical contributions to cluster identification have so far not incorporated techniques of analysing the extent and relative importance of the various agglomerative forces within a specific cluster. It is the objective of the present thesis to tap into these areas of deficient knowledge and to contribute from a methodological stance to a richer understanding of spatial agglomeration and its underlying forces.

Specifically, our research task is to find out how to adequately identify a specific cluster. In this dissertation it is argued that an alleged cluster cannot be adequately identified, unless both cluster dimension, the geographical as well as the functional dimension, are captured. Capturing the geographical dimension only yields the detection of a group of spatially co-located firms. However, it may not be a cluster, because we do not know whether or not agglomeration advantages are in fact generated and exploited. If the analyst captures the functional dimension only, a group of inter-linked firms may be identified. However, it remains unknown, whether or not these firms are located in spatial proximity.

Figure 1: White spots in the literature relevant to cluster identification



Hence we will reframe the issue of cluster identification into two interrelated questions:

- How to detect a spatial concentration of co-located firms as well as the spatial scope of an alleged cluster (*geographical dimension*)?
- How to measure which, if any, agglomerative forces are operating in an alleged cluster (*functional dimension*)?

Two aspects of this dissertation are new and thus worth noting:

- *A careful empirical approach for the identification of a specific cluster* is offered. The approach has several components, of which two deserve special attention. First, as our understanding of the cluster phenomenon is mainly constrained by the quality and availability of relevant data, we will suggest a mix of official statistics and a minimum requirement of firm-level data. A survey has been designed for 15-minute telephone interviews in order to collect cluster-specific firm data, thereby capturing the spatial boundaries of the cluster endogenously. Second, it comprises a method to test empirically which agglomeration forces may be operating within the alleged cluster compared to a control group of similar firms that are not co-located. This approach attempts to help effectively bridge the gap between comparability and specificity of the findings of cluster identification studies.

- *A new high quality data set* has been generated. We have used the survey technique to conduct extensive telephone interviews with aeronautic (supplying) firms that are concentrated in the Northern German region surrounding the city of Hamburg. This is a particularly interesting case because two world leaders in the production (Airbus Deutschland GmbH) and overhaul of aircrafts (Lufthansa Technik AG) as well as approximately 250 small and medium-sized supplying enterprises are centred here.

This dissertation is organised as follows. Chapter 2 reviews the empirical literature relevant to the issue of cluster identification. Thereby we attempt to show what techniques have been developed that can be used for cluster identification, what the analytical problems are and what we can learn from other related strands of analysis to solve them. We begin by an attempt to clarify what the constituent factors of clusters are in section 2.1. We will discuss what scholars have meant by geographic proximity and we will provide an overview of the various types of interfirm linkages that may generate agglomeration advantages. In chapters 2.2 and 2.3 we sketch the methods used in the two before-mentioned strands of the cluster-identification literature. We will show that the latter do not allow to identify a specific cluster. Moreover, these techniques determine the spatial scope of clusters in a rather contestable way (*geographical dimension*). Furthermore, they do not allow to analyse which, if any, agglomeration forces are operating in the alleged clusters (*functional dimension*). Therefore, we proceed to investigate what insights with respect to these problems can be learned from different but related lines of inquiery. Thus, we review the empirical literature on agglomeration forces in section 2.4 as well as two exemplary cluster case studies in section 2.5. Section 2.6 provides a summary.

Chapter 3 presents the empirical approach that has been developed to identify a specific cluster. In section 3.1.1 we suggest to use a two-dimensional cluster definition that is arguably a reasonable starting point for our cluster identification exercise. We describe how we suggest to identify a *search area* for an alleged cluster as well as how to determine a control group of non-cluster firms in section 3.1.2. Here we also offer the respective data for the case of the alleged cluster in Northern Germany. Next, show how the survey has been conducted (section 3.1.3). In section 3.1.4 we illustrate a pragmatic concept of capturing the spatial boundaries of a cluster. It is determined endogenously by the interview partners. In what follows we explain how to analyse what, if any, agglomeration forces are operating whithin an alleged cluster. We demonstrate what indicators can be used to capture the flow size of the various inter-firm linkages that may generate agglomeration advantages (section 3.1.5). Thereafter the specification of descriptive as well as econometric data analysis is introduced (sections 3.1.6 and 3.1.7). This shall enable us to investigate the extent and relative importance of agglomerative forces within an alleged cluster. The survey that has been applied to collect the prerequisite data is attached in Appendix 2.[4] The empirical results are provided in sections 3.2 and 3.3. A summary is given in section 3.4.

In chapter 4 we will summarise the major findings, provide concluding methodical considerations and we discuss options for future research.

[4] An English version of the survey can be sent upon request: lublinsk@econ.uni-hamburg.de

2. A review of the literature relevant to cluster identification

In this chapter we review the literature that is relevant to cluster identification. Cluster identification studies can be segregated into two main strands of analysis, each of which centers on one of the two cluster dimensions. The first strand focused on identifying groups of firms that are geographically proximate using mainly sector-level employment data (*geographical dimension*) (section 2.2). The other strand of analysis centers on the question to what extent firms are interlinked by flows of goods and services using Input Output data (*functional dimension*) (section 2.3). Table 1 provides an overview of the most prominent contributions in the field of quantitative cluster identification.

Apart from these two main lines of inquiery, there have also been efforts to identify clusters as groups of industries that show high levels of industry market shares of world exports (Porter, 1990; Peneder, 1994). Moreover, others have aimed at detecting groups of firms that are proximate in technological space for instance (Hutschenreiter, 1994) or that are interlinked by knowledge flows (Debressen, et al., 1996 among other). Some researchers have applied network analysis or sociometry to the identification of clusters (Krätke and Scheuplein, 2001).

Cluster identification studies have not only differed in the data used and in the way clusters have been defined, but also in the method that has been applied: Factor analysis, cluster analysis, graph theoretic approaches or triangulations of I/O matrices, concentration indices, qualitative methods and many more - all have been given a try (see Table 1).

Thus, despite the fact that both scientists as well as policy makers place great importance on the understanding of the cluster phenomenon, no standard empirical approach to cluster identification has yet evolved. It is due to this diversity of studies that a survey of the literature would seem to be in order.

Table 1: An overview and classification of cluster-identification studies

authors / data		*subject of measurement*	*study area*	*method of data analysis*
i/o data [5]				
1. Roelandt, T. et al.	(1997)	linkages [6]	Netherlands	triangulation [7]
2. Hauknes, J. et al.	(1999)	linkages	Norway	triangulation
3. Campbell, J.	(1975)	linkages	Washington	triangulation / graph theory
4. Roepke, H. et al.	(1974)	ind. linkages & techn. assoc. [8]	Province of Ontario	factor analysis
5. Czamanski, S.	(1974)	ind. linkages	USA	factor analysis
6. Feser & Bergman	(2000)	ind. linkages	USA	factor analysis
i/o- & employment data [9]				
7. Czamanski, S.	(1977)	spatial ass. [10]	USA: 191 SMSAs [11]	regression analysis
8. Streit, M. E.	(1969)	linkages & spatial ass.	France (90 Regions) F.R.G. (30 Regions)	correlation analysis
9. Richter, C. E.	(1969)	linkages & spatial ass.	USA: 57 SMSAs	correlation analysis
employment data				
10. Kim, S.	(1995)	spatial concentration	U.S.A. (1860-1987)	location quotient (Hoover, 1936)
11. Krugman, P.	(1991)	spatial concentration	U.S.A.	locational Gini coefficient
12. Ellison, G. and Glaeser, E.	(1997)	spatial concentration	U.S.A.	agglomeration index
13. Maurel, F. and Sédillot, B	(1999)	spatial concentration	France	agglomeration index
14. Devereux, M. et al.	(1999)	spatial concentration	UK	agglomeration index
15. Bergsman, J., et al.	(1972)	spatial ass.	USA: 203 SMSAs	factor analysis
16. Bergsman, J., et al.	(1975)	spatial ass.	USA: 311 SMSAs	cluster analysis
17. Ó hUallachain, B.	(1991)	spatial ass.	USA: SMSAs	factor analysis
performance data				
18. Porter, M.	(1990)	competitiveness	10 countries	*Cluster-Chart*
19. Peneder, M.	(1994)	competitiveness	Austria	cluster analysis
innovation data (& i/o data)				
20. Van den Hove, et al.	(1998)	linkages & spillovers	Netherlands	*knowledge intensity coefficient*
21. Hutschenreiter, G.	(1994)	spillovers	Austria	cluster analysis
22. Jaffe, A.B.	(1989a)	spillovers	USA	cluster analysis
23. DeBresson, C. et al.	(1996)	linkages & spillovers	Canada, China, Italy, France, Greece	*Innovation Activity Matrix* & comparison with i/o data
surveyed data on communication networks				
24. Krätke, S. and Scheuplein, C.	(2001)	communication networks	Eastern Germany	network analysis (sociometry) among other

[5] spatially and sectorally disaggregated.
[6] Linkages are here meant in an I/O sense.
[7] Triangulation is here defined as a process of rearranging I/O tables according to certain optimality criteria.
[8] Indirect linkages and technological association.
[9] spatially and sectorally disaggregated.
[10] spatial association of industries.
[11] Standard Metropolitan Statistical Area (SMSA).

We will begin by analysing how clusters are defined in the literature and what the constituent features of clusters are (section 2.1). This is particularly important, because obviously the researcher has to know what exactly the phenomenon is, before proceeding to find out whether or not it can be identified.

Concerning the quantitative efforts we will here focus exclusively on the before-mentioned two main lines of inquiery. That is, we review techniques of cluster identification using mainly sector-level employment data in section 2.2 and we describe I/O techniques in section 2.3. We will not touch on any other of the before-mentioned quantitative studies in more detail. As none of the cluster identification techniques has incorporated an assessment of the ways in which agglomeration forces are operating in clusters and, additionally, none of the methods can be used to identify specific clusters, we will next turn to different strands of analysis. In section 2.4 we review empirical contributions that have primarily investigated the extent and relevance of agglomeration forces without explicitely identifying clusters. And in Section 2.5 we review two case studies as examples for research that has analysed specific clusters. Section 2.6 summarises the findings in conclusion.

2.1. The confusion of cluster definitions

Probably the most influential author in the field of cluster research – Michael Porter – suggests to define clusters in the following comprehensive way:

"Clusters are geographic concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition. They include, for example, suppliers of specialized inputs such as components, machinery, and services, and providers of specialized infrastructure. Clusters also often extend downstream to channels and customers and laterally to manufacturers of complementary products and to companies in industries related by skills, technologies, or common inputs. Finally, many clusters include governmental and other institutions – such as universities, standard-setting agencies, think tanks, vocational training providers, and trade associations – that provide specialized training, education, information, research, and technical support" (Porter, M. (1998a), p. 78).

However, scholars have not at all agreed upon a standard cluster definition. Table 2 illustrates the confusion that is related with this question. It provides a short overview of different cluster definitions of some prominent authors.

Table 2: A collection of cluster definitions

Porter (1998b, p. 199) "A cluster is a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities."
Crouch et al. (2001, p. 163) "The more general concept of 'cluster' suggests something looser: a tendency for firms in similar types of business to locate close together, though without having a particularly important presence in an area."
Rosenfeld (1997, p. 4) "A cluster is very simply used to represent concentrations of firms that are able to produce synergy because of their geographical proximity and interdependence, even though their scale of employment may not be pronounced or prominent."
Feser (1998, p. 26) "Economic clusters are not just related and supporting industries and institutions, but rather related and supporting institutions that are more competitive by virtue of their relationships."
Swann and Prevezer (1996, p. 139) "Clusters are here defined as groups of firms within one industry based in one geographical area."
Swann (1998, p. 1) "A cluster means a large group of firms in related industries at a particular location."
Simmie and Sennett (1999, p. 51) "We define an innovative cluster as a large number of interconnected industrial and/or service companies having a high degree of collaboration, typically through a supply chain, and operating under the same market conditions."
Roelandt and den Hertog (1999, p. 9) "Clusters can be characterised as networks of producers of strongly interdependent firms (including specialised suppliers) linked each other in a value-adding production chain."
Van den Berg, Braun and van Winden (2001, p. 187) "The popular term cluster is most closely related to this local or regional dimension of networks ... Most definitions share the notion of clusters as localised networks of specialised organisations, whose production processes are closely linked through the exchange of goods, services and/or knowledge."
Enright (1996, p. 191) "A regional cluster is an industrial cluster in which member firms are in close proximity to each other."

Source: Martin (2002) p. 15.

Obviously, these definitions differ with respect to a variety of aspects, as was argued in the introductory section. Taken together, two elements that essentially describe the cluster phenomenon spring up:

- Firms in a cluster must be geographically concentrated and proximate (*geographical dimension*).
- These co-located firms must be interconnected in some way which results in a superior performance compared to spatially dispersed non-cluster firms (*functional dimension*).

The main problem raised by all of these definitions is the lack of precise descriptions of the essential cluster features. The notion of geographic proximity is, for example, rather vaguely defined. Definitions give no hint as to where the spatial boundaries of clusters are. Furthermore, we do not know of what kind interactions between firms in clusters are and what performance measures they may have an impact on.

We will therefore now elaborate each of these aspects in more detail. We will begin by reviewing what scholars means by geographic proximity and what the spatial scope of clusters is (2.1.). Next, we provide an overview of the various types of interfirm linkages that may generate agglomeration advantages. And we will discuss what performance measures may be affected by the latter (2.2.).

2.1.1. Geographic proximity and the spatial extent of clusters

In order to adequately identify clusters we need to have a better understanding of what is meant by geographic proximity and how to describe the spatial scope of clusters. Therefore, we need to clarify a number of terms that are being used in this context.
Firms in clusters, so the story goes, are geographically proximate, which enhances frequent face-to-face contacts and thus value-creating benefits may arise from interaction between firms:

> *"A cluster is a form of network that occurs within a geographic location, in which the proximity of firms and institutions ensures certain forms of*

commonality and increases the frequency and impact of interactions" (Porter, 1998b, p. 226).

Thus, Porter implicitly suggests that it is the "increased" frequency of contacts that defines the notion of proximity. However, this does not sufficiently explain the term. Proximity for the U.S. secretary of state would be understood as the world as a whole, while for a street bum it would be not more than two blocks within a city district. The obvious problem with this and other cluster definitions is that they lack clear spatial boundaries. Even Michael Porter does not provide any precise definition of this notion. He argues that clusters can be found at any geographical level: "*They are present in large and small economies, in rural and urban areas, and at several geographical levels (for example nations, states, metropolitan regions, and cities)*".[12] For some critics, however, this is too elastic a definition:

> *"The problem is that geographical terminology is used in a quite cavalier manner, depending it seems, as Porter himself admits, on what the aim of the excercise is, or the client or policy-maker for whom the analysis is intended. The key weakness is that there is nothing inherent in the concept itself to indicate its spatial range or limits, or whether and in what ways different clustering processes operate at different geographical scales. We are not suggesting that the cluster concept should refer to a particular pre-specified geographical size or scale; but to use the term to refer to any spatial scale is stretching the concept to the limits of credulity (...)"* (Martin, 2002, p. 16).

Enright (1996) makes an attempt to describe in words what is inherent in the cluster story that would indicate clusters' geographical boundaries. He explains that it is identical to the spatial extent of the sources that may generate agglomeration advantages:

> *"The geographic area over which these features provide advantage to the region's firms defines the geographic scope of competitive advantage and the appropriate boundaries of existing regional clusters. (...) It is the geographic*

[12] Porter, M. (1998), p. 204.

> *scope of these sources of advantage that will determine the geographic scope of the regional cluster"* (Enright, 1996, p. 194).

But what is meant by the term 'sources of [agglomeration] advantage'? Assumably, it is meant to be synonymous with all other relevant firms or institutions of various types, which are sufficiently proximate to ensure frequent face-to-face contacts.

Now imagine a chain of firms that spans a whole continent with each firm pair being interlinked by relatively frequent face-to-face contacts. According to the above-mentioned arguments, we would consider this firm chain a cluster. However, this is hardly the cluster phenomenon that authors like Michael Porter have in mind. Of course, we need to understand the proximity notion only in combination with the term of geographical concentration.

Having discussed some of the problems related to the definitions of the notions geographic proximity and the spatial scope of clusters, we will now turn to the other essential features of clusters that are related to the various types of inter-firm linkages that may generate agglomeration advantages.

2.1.2. The driving forces of agglomeration: an overview of arguments

In the literature it is argued that the innovation performance, productivity and profitability can be higher among geographically proximate firms compared with geographically dispersed firms (Baptista and Swann, 1998, p. 538; Porter, 1999, p. 226). Hence, geographically concentrated groups of related and inter-linked firms may grow faster. The driving forces of such cluster growth are so-called agglomeration advantages. They may generate and reinforce clusters because geographical proximity may allow for frequent face-to-face contacts at reasonable costs that may prove critical to business success and may not be compensated by modern communication technologies. But what are these inter-firm linkages and what are the various agglomeration advantages that may be generated?

Apart from classifications[13] there are a number of theoretical arguments that have been discussed in the literature.[14]

Figure 2: Overview of agglomeration advantages

advantages in geographic proximity

Marshallian externalities

1) ***labor market pooling*** - labor cost savings due to a privileged access to specialised skills especially in an environment where firms have non-positive correlations in the temporal variations of their demands.

2) ***accessibility to a great variety of specialised intermediate goods and services*** - privileged access to a local supplier base that has great product variety and a high degree of specialisation

3) (***tacit) knowledge spillovers*** - privileged access to tacit knowledge in geographic proximity by means of both formal fashioned transmittal-processes as well as through such informal channels as knowledge leakages made possible by casual inter-firm interactions, workers changing jobs, etc.

Porter's market conditions

4) ***demanding customers*** - privileged motivational effects due to high demands of highly competitive local customers, that may lead to higher competitiveness on distant markets.

5) ***rivalry*** - privileged motivational effects due to better benchmarking opportunities and a more intense inter-personal competition for immaterial gratification between specialised workers in geographic proximity.

6) ***complementarities*** - privileged sales opportunities of firms due to search cost savings of buyers' of complemtentary products offered in proximity and privileged opportunities for cooperation (sales, marketing etc.) between nearby suppliers of complementary products.

transportation and transaction cost advantages

7) ***transportation cost advantages*** - transportation cost savings due to geographic proximity especially in the case of just-in-time delivery-contracts.

8) ***trust*** - transaction cost savings due to a geographically proximate environment that enhances trust-building processes.

Marshall (1920) and Krugman (1991) suggest a simple triad of external economies (see also Fujita and Thisse, 1996, for a review). These are inter-firm linkages that may enhance knowledge spillovers, a privileged access to specialized skills as well as to intermediate goods and services. Moreover, Porter (1990) argues that rivalry among local firms, complementarities and demanding local customers may critically provide competitive advantage. Earlier work has focused on transportation cost advantages (Lösch, 1954; von

[13] Classifications of the theoretical arguments in the literature have distinguished among other between supply-side and demand-side externalities (Swann, 1993), intra-industry forces, known as Marshall-Arrow-Romer externalities (Marshall, 1920; Arrow, 1962; Romer, 1986, 1990), and inter-industry forces (Jacobs, 1969, 1984; Scherer, 1984) and – in a non-dynamic context - localisation and urbanisation economies (Lösch, 1954; Isard, 1956), the first occuring between firms of the same industry locating close to each other and the latter termed for effects resulting from the co-location of firms of different industries in the same area or city.

[14] This list of arguments does not explicitly include the advantages that may arise from public intermediate goods and services tailored to the specific needs of the local economy. However, it is indirectly incorporated in the arguments that follow as one of the possible sources for knowledge, labor etc.

Thünen, 1826; Weber, 1920), that may still play a significant role in the location-decision of firms today. Lastly, trust may be more easily developed between geographically proximate agents (Bachmann and Lane, 1996; Dei Ottati, 1994; Lyons, 1994; Schmitz, 1999; Williamson, 1999). However, the clustering process may not be infinite. Its limits are reached due to congestion effects or strong competition on local output and factor markets.

We will now describe each of these arguments in more detail and we will describe what performance measures of firms they may affect.

2.1.2.1.Marshallian externalities

The most often mentioned agglomerative advantage is labor market pooling (Marshall, 1920; Krugman, 1991). Firms in clusters may have a better access to workers and at lower recruiting and training costs. The reason for this is that firms can tap two sources for skills. Firstly, firms can recruit graduates from local educational institutions that provide the training that is locally requested. And, secondly, a geographical concentration of technologically related firms creates a local pool of specialized and experienced skills. If workers are made redundant in one firm they may be absorbed by other local firms, because business shocks are not necessarily correlated between firms. The “bad times“ in one firm, in which people are fired, may coincide with the “good times“ in other local firms, in which people are hired. Thus there is a clear incentive for both firms and workers to move into clusters. For firms these effects may decrease labor costs and hence increase its profitability. Moreover, firms’ innovative performance may be affected by the local labor pool, because it may ‘incorporate’ human capital. However, we would not expect labor market pooling to effect firms‘ total factor productivity, because a privileged access to labor cannot be seen as a cost-free input to production.
The limits to these advantages are reached when local labor markets are congested. Then firms fear that their workers may be pulled away by headhunters.

Firms in successful clusters may also benefit from a privileged access to large local supplier markets, in which firms offer a great variety of highly specialised intermediate goods and services (Marshall, 1920; Krugman, 1991). A greater depth and width of the local supplier base may positively influence the firms‘ profitability, as the local divison of labor gets more efficient. It may enable firms to ‘breathe’. They can buy-in and out-source activities locally thereby complying with complex and fast changing customer demands. They are able to purchase intermediate goods at lower cost, if entering firms are willing to price more aggressively (Porter, 1999, p. 226). The latter know that, as they do so, they may realize efficiencies due to economies of scale and by ’sliding’ down the learning curve. However, a priviliged access to a great variety of specialised local suppliers does not constitute an externality. Hence it may not influence firms’ productivity.

Another reason for localisation are knowledge spillovers (Marshall, 1920; Krugman, 1991). Firms may be able to absorb specific knowledge that has been accumulated by other firms via market and non-market channels. Good sources of knowledge may be suppliers, labour as well as customers (von Hippel, 1988). Further knowledge may be gained from public sources, such as patent information, industry publications, etc., by reverse engineering or via spionage. For the pure externality informal meetings arguably are an important channel (Pavitt, 1987; Saxenian, 1996):[15]

> *“By all accounts, these informal conversations were pervasive and served as an important source of up-to-date information about competitors, customers, markets, and technologies. Entrepreneurs came to see social relationships and even gossip as a crucial aspect of their business. In an industry informal communication was often of more value than more conventional but less timely forums such as industrial journals.“*

An important amount of knowledge that is needed for firms to innovate may be tacitly-held as opposed to codified knowledge (Lundvall, 1988; Nelson and Winter, 1982; Teece et al., 1997). This type of knowledge is often embedded in daily routines and can not be easily absorbed via modern communication technology. It is argued that in order to extract tacitly-held knowledge from such routines people with overlapping knowledge need to get continous innovative processes underway:[16]

[15] Saxenian, A. (1996), p. 33.
[16] Lawson, C., Lorenz, E. (1999), p. 315.

> *"...thus forcing tacitly-held knowledge to go through moments in which such knowledge is articulated and recombined."*

For such processes regular face-to-face contacts, which are more easily arranged in geographic proximity, are of great advantage. Thus, access to tacit knowledge of nearby firms may be an essential driver of agglomeration (Lawson, C., Lorenz, E., 1999; Maskell, P., Malmberg, A., 1999; Foss, N. J., 1996; Storper, M., 1995; Baptista, R. et al., 1999). These externalities may both effect firms' innovation performance as well as their productivity.

2.1.2.2. Porter's market conditions

Furthermore, Michael Porter (1990) postulates that firms in clusters may benefit from strong local rivalry, which can be "*highly motivating*" and may positively influence productivity and innovation performance of firms.[17] The cluster-advantage is that executives and specialized workers within clusters may compete to a greater degree for immaterial gratification, such as recognition, reputation or pride, compared to their counterparts in dispersed firms. Geographical proximity allows for a greater transparency, which may lead to stronger benchmarking activities in which the rivals' performance is monitored. This in turn amplifies peer and competitive pressures even between firms that are not or indirectly competing on product markets (Porter, 1998). Moreover, local rivalry may affect firms' innovativeness, because it may excert continous pressures upon firms (Porter, 1999, p. 234).

Firms in clusters may also benefit from relatively sophisticated and demanding local customers (Porter, 1990) that push them "*to meet high standards in terms of product quality, features, and service*".[18] Companies that expose themselves to these pressures and that are able to meet these demands may attain competitive advantage over firms that do not. Thus, it is the desire to fulfill sophisticated local buyers' requirements that helps suppliers to attract new distant customers and increase market shares on distant markets. And, demanding customers may help to increase suppliers' motivation and hence their

[17] Porter, M. (1990), p. 83.
[18] Porter, M. (1990), p. 89.

productivity and innovation performance. Geographic proximity may here function as an additional driver to this effect. It may enlarge the window to the market allowing for better access to customer information (von Hippel, 1988).

Another agglomerative force that may be operating in clusters is related to the fact that local supplies may complement each other (Porter, 1990). Firms in clusters may benefit from complementarities both passively and actively. Buyers‘ representatives can meet many suppliers in a single trip (Porter, 1998). Thus, the success of one supplier may boost sales of other proximate firms, too. And geographically proximate companies may profit from joint activities in research, development, recruiting, training, production, marketing, sales and after-sales services because transaction costs may be lower in proximity. Additionally, proximate firms may benefit from collaborating in restructuring efforts of the cluster's whole value chain. Local companies may be able recognize and to tap improvement potentials, which would not have been possible between distant firms. Thus, increased sales as well as lower cooperation costs in proximity may effect firms‘ profitability.

2.1.2.3. Transportation and transaction cost advantages

Transportation cost advantages (Lösch, 1954; von Thünen, 1826; Weber, 1920) may also arise in geographic proximity.[19] Suppliers / buyers may, under transportation cost considerations, benefit from short distances to their buyers / suppliers with respect to their profitability. This is especially the case for suppliers with just-in-time agreements, in which the risk of delivery delay is layed upon the supplier. In the aircraft manufacturing industry, for example, some suppliers of, say, cabin equipment need to be able to deliver their goods and services on very short notice, in order to react flexibly to changes in the airlines‘ requests that purchase the aircrafts.

Last but not least, transactions and cooperations may be less costly in proximity due to the fact that trust is more easily developed between geographically proximate agents (Bachmann, R. and Lane, C., 1996; Dei Ottati, G., 1994; Lyons, 1994; Schmitz, 1999;

[19] Transportation cost advantages, are strictly speaking, no agglomeration advantages. Fujita, Krugman and Venables (1999, p. 49) show that clustering may be the result of both high and low transportation costs.

Williamson, 1999). To cope with the risk of opportunism that every transaction and cooperation is exposed to agents may rely on legal redress. This, however, is more expensive the more complex the agreement is. "*For a deep divison of labour and cooperation between firms to be effective at reasonable cost, trust is essential*".[20] To develop trust, agents need to be able to learn about each others' motives, character, performance and socio-cultural background in order to be able to evaluate each others' reputation capital and overall trust worthiness. The point to make here is that frequent face-to-face contacts, that are more easily arranged in proximity, may enhance such processes. Geographically sensitive transaction costs may thus be low in clusters, which in turn may effect profitability of firms.

2.2. Cluster identification techniques using employment data

In the above section we have seen that although there is no standard cluster definition, we have argued that, taken all essential features of clusters together that have been mentioned by scholars, it is helpful to consider a geographical and a functional cluster dimension. Firms in a cluster must be geographically concentrated as well as proximate. And they must be interconnected in some way, such that the various agglomeration forces (see Figure 2, p. 28) may result in a superior performance compared to spatially dispersed non-cluster firms.

It is the objective of this chapter to describe tools that make use of employment data and that allow to measure to what extent firms are spatially proximate. Specifically, we will sketch the most prominent spatial concentration quotients that have been suggested in the literature to analyse the degree to which firms of the same sector are proximate (*spatial concentration*). And we review a technique used to assess the degree to which firms of two industries systematically co-locate over a number of areas (*spatial association*).

We will begin with the location quotient proposed by Kim (1995) who restated Hoover (1936). Next, we will sketch the locational Gini coefficient proposed by Krugman (1991) in section 2.2.2. Thereafter, we demonstrate how Ellison and Glaeser (1997) have

[20] Schmitz, H. (1999), p. 142.

computed their index of agglomeration (section 2.2.3). In section 2.2.4 we explain how Bergsman et al. (1972/75) have attempted to measure the spatial association of industries.

2.2.1. A location quotient

In order to find out what are the leading regions of a spatially concentrated industry Kim (1995) and Hoover (1936) suggest to calculate for each locational unit in a given sample industries' employment shares with respect to each industry's total employment in the aggregated locational unit. Denoting employment of industry *k* in the locational unit *i* as y_i^k, the region's employment share in that industry is represented by the following term: $l_i^k = y_i^k / \sum_i y_i^k$. Next, we need to further develop this term in order to control for the size of regions, as the various locational units in our sample may differ with respect to their size. Hence, we normalise the nominator with the region's total manufacturing and the denominator with the locational aggregate's total manufacturing employment. This results in the following *location quotient* proposed by Kim (1995) who restated Hoover (1936):

$$r_i^k = \frac{y_i^k / \sum_i y_i^k}{\sum_k y_i^k \Big/ \sum_i \sum_k y_i^k} = \frac{y_i^k / \sum_k y_i^k}{\sum_i y_i^k \Big/ \sum_k \sum_i y_i^k}$$

2.2.2. The locational Gini coefficient

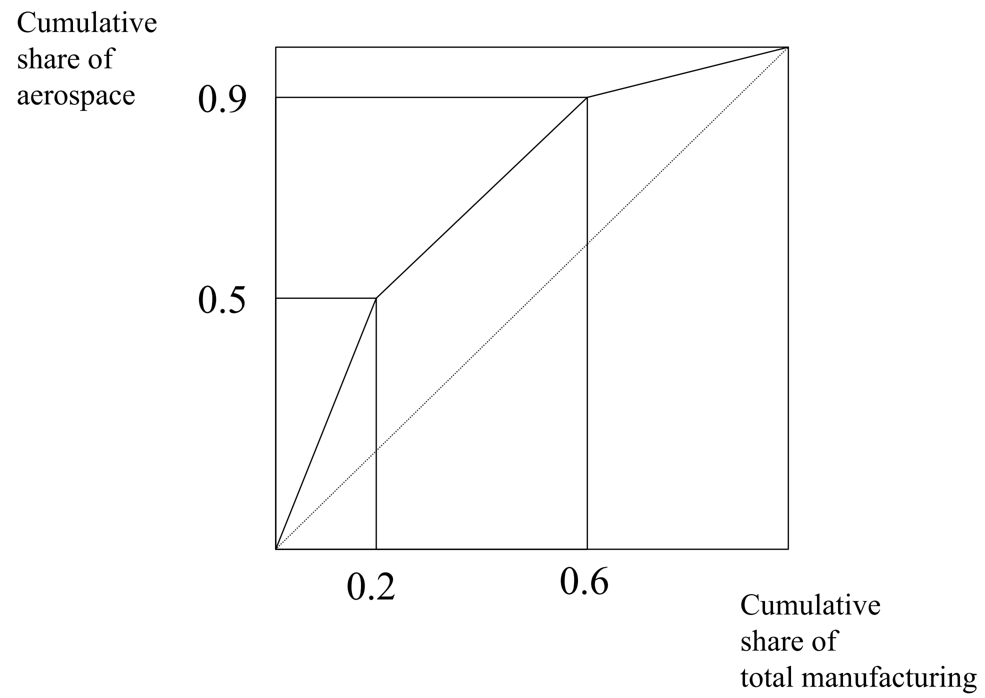
For an assessment of the overall spatial concentration of an industry compared to other industries Krugman (1991) suggested to compute *locational Gini coefficients*. In order to do so we first need to calculate for each locational unit in our sample the shares of the aggregate locational units' employment in the industry, that is the shares of, say, national employment in the aerospace industry: $l_i^k = y_i^k / \sum_i y_i^k$. Second, we need to rank sub-regions such that

$$l_{(1)}^k \leq l_{(2)}^k \leq .... \leq l_{(N)}^k .$$

Next, we run down this ranking of regions thereby keeping a cumulative total of both the sum of employment share in the industry u_i as well as the sum of total manufacturing employment share v_i . We obtain the *locational Gini curve* or *Lorenz curve* if we put these values (u_i , v_i) (i = 1, ..., N) to a graph and connect them starting off from the point (0, 0).

Consider for example a world that consists of only three regions. Region A accounts for 20% of total manufacturing employment and 50% of aerospace employment. Region B has 40% of total manufacturing employment and 40% of aerospace employment. Finally, Region C has the remaining 40% of manufacturing employment and 10% of aerospace employment. The resulting curve is represented in Figure 3.[21]

Figure 3: Lorenz curve and locational Gini coefficient



The value of the *locational Gini coefficient* is then represented by the area between the 45°-line and the *Lorenz curve*. The more spatially concentrated an industry is, the larger

[21] This example has been adopted from Krugman (1991), p. 55f.

the coefficient value with its maximum being 0.5.[22] In contrast, an industry that shows the same spatial distribution compared to total manufacturing would have an index value of 0. Then the Lorenz curve would be identical to the 45°-line. It is calculated using the following equation:

$$GC = \frac{1}{2} \cdot \sum_{i=1}^{N} (u_{i-1} + u_i) \cdot g_i - \frac{1}{2}; \qquad \text{for all } i = 1, ..., N \qquad GC \in [0, 0.5]$$

with g_i denoting locational unit *i*'s share in total manufacturing employment and

u_i representing the cumulated sum of shares in the industry: $u_i = \sum_{j=1}^{i} l_{(j)}$.[23]

One of the main defects of this measure is the fact that it does not control for industrial concentration. Ginis consider an industry localized, if it is strongly concentrated in a few plants in a limited number of geographical units. This can pose a problem when Ginis of two industries are compared that differ in the degree to which internal returns to scale matter.

Moreover, the density of spatial units may matter. If for example one sub-national region accounts for say 10% of total manufacturing employment, 90% of aerospace employment as well as 90% of the nation's total geographic scope, this industry would be considered spatially concentrated using a Gini criterion. However, this may be a false interpretation, if aerospace firms' locations are equally distributed over this geographic area.

2.2.3. An agglomeration index proposed by Ellison and Glaeser

An alternative global index has been proposed by Ellison and Glaeser (1997).[24] They, first, define a measure of 'raw' geographic concentration $G_{EG}^k = \sum_i (l_i^k - x_i)^2 \big/ (1 - \sum_i x_i^2)$. Keeping the earlier notation $l_i^k = y_i^k / \sum_i y_i^k$ represents location *i*'s share of industry *k*, and

[22] Other formulations have different intervals. Audretsch and Feldman (1996) for example use a Gini index that has been normalized to a [0,1] interval.
[23] In the above example the locational Gini coefficient takes on the value GC = 0.21.
[24] Indices similar to that of Ellison and Glaeser (1997) have been proposed by Maurel and Sédillot (1999) and Devereux, Griffith and Simpson (1999) and have been applied to France and the UK, repectively. However, they are not sketched here in more detail.

$x_i = \sum_k y_i^k / \sum_i \sum_i y_i^k$ is location i's share in overall manufacturing employment. Thus G_{EG}^k is based on a comparison between the fraction of the industry's employment in the region and the fraction of overall manufacturing employment.

To control for industrial concentration Ellison and Glaeser calculate a standard Herfindahl index for industry k, $H^k = \sum_j (z_j^k)^2$, where z_j^k is the share of plant *j* in total industry *k* output.

From these two components, G_{EG}^k and H^k, they build the following index of the degree to which an industry is geographically concentrated:

$$\gamma_{EG}^k = G_{EG}^k - H^k / (1 - H^k)$$

The scale of the index is essentially defined by a no-agglomeration benchmark. Ellison and Glaeser show that the expected value of this concentration index is zero if plants are located randomly. In contrast, an industry is considered localised if the respective index value is different from zero.

2.2.4. Measuring spatial association

Bergsman et al. (1972/1975) have analysed the extent to which pairs of industries have been systematically co-located in metropolitan areas (SMSAs) in order to identify industrial groupings that showed similar co-location patterns. The data base in their 1972 study has consisted of employment data for 186 U.S. industries in 203 SMSAs. Their method of choice has been multivariate analysis. Linear zero order correlation coefficients have been calculated for each industrial pair. That is, the distribution of industries' employment shares in metropolitan areas have been compared. Coefficients have been arranged in a symmetrical matrix, to which factor analysis has been applied. This method reduces complexity by creating new variables, called factors. Factors represent some of the original variables, with which they are highly correlated. In other words, each factor is a linear combination of the original variables. The main problem that the authors have been confronted with has been the so-called 'New York phenomenon'. A few large urban areas, such as New York for instance, tend to dominate the entire analysis, because they may

have a large employment share of total national employment in several industries. Hence, the technique may not be able to reveal the extent to which industries co-locate in smaller cities, rather results indicate the ways in which large cities are unique. To control for city size effects, additional analysis have been conducted using per capita employment rather than total employment figures. However, it has been criticised that in doing so it is implicitely assumed that "*urban pull affects all industries with equal force*".[25]
As a result 58 factors have been identified, of which 27 have represented either independently locating sectors or variables (industries) that had strong links to many factors. The remaining 42 factors have been interpreted as clusters and labelled according to main products or other criteria.

Bergsman et al. (1975) have conducted a second investigation touching on this issue, which differed from the 1972 study in the following aspects. First, factor analysis has been substituted for hierarchical cluster analysis. The latter identifies mutually exclusive industrial groupings, while the former does not. In other words, using cluster analysis industries are exclusively assigned to a single industrial grouping (cluster), providing rather 'clear-cut' results. In contrast, factor analysis accounts for the fact that an industry may be closely associated with more than one cluster. Second, rank order correlation coefficients have been computed rather than zero order correlation coefficients. The technique joins the two most highly correlated variables into a cluster. This cluster is treated as a single variable. Next, the same process is repeated until all of the original variables are grouped to one grand cluster. Eventually, the number and composition of clusters are defined from an intermediate stage of the aggregation process. The advantage of ranking correlations over zero order correlations is that it may downgrade the city size effects, mentioned above. Yet, it may not completely control for urban size, because the ranking of sectoral employment is possibly similar to that of population. Third, a larger data set has been used comprising 480 sectors in 311 metropolitan areas. Clusters have been identified as groupings of two-, three- and four-digit industries that show similar locational patterns. Interestingly, results do differ from SIC classifications on the corresponding higher aggregational level. In other words, clusters of 4-digit SIC industries do not exclusively comprise the 4-digit SIC industries that together make for the corresponding 3-digit industry.

[25] Czamanski, S. and de Q. Ablas (1979), p. 64.

2.3. Cluster identification techniques using I/O data

In the above section we have seen that several techniques allow to investigate to what extent firms of either the same or many industries are located in spatial proximity. However, non of these techniques considered the *functional dimension* of clusters, because results do not explain to what degree co-located firms are indeed inter-linked such, that agglomeration forces are being provoked and exploited.

Hence, we will now review methods that use Input Output data to identify groups of industries that are inter-linked by flows of goods and services. There have been various approaches to cluster identification based on I/O data. Clusters have been identified by grouping sectors that are linked by maximal I/O flows, by “shaking out” all weak values from the I/O table, by applying graph theoretic concepts and by measuring the degree of similarity of sales and/or procurement profiles between sectors. In this section we will briefly introduce each of these analytical tools in this same order. This overview of I/O methods has been published in Pfähler (ed.) (2001).[26]

2.3.1. Identifying maximum values of forward-/ backward linkages

Roelandt et al. (1997) joined sectors into clusters on the basis of either relatively strong forward- or backward linkages. The forward linkages method[27] uses an I/O table *X* with elements x_{ij} to identify the main user sector j (column) of every supplying sector *i* (row) searching the maximum value of each row: $x_{ij\,\max} = \max_{j}(x_{ij})$. Intrasectoral flows are neglected: $x_{ii} = 0$. For example, the matrix below represents an I/O table with sectors *a* to *d*, intra-sector flows set to zero and maximal forward flows in bold numbers.

[26] See Lublinski, A. (2001).

	a	*b*	*c*	*d*
a	0	30	30	**40**
b	20	0	**60**	10
c	10	**40**	0	30
d	**40**	25	35	0

Next, it is analyzed whether these values constitute *substantial* deliveries. This is the case for deliveries that, as a percentage of total deliveries, are larger than a critical value *k*: $t_i = \sum_{i=1}^{n} x_{ij\,\max} - x_{ii}$ and $\frac{x_{ij\,\max}}{t_i} \cdot 100 > k$. The critical value, *k*, is assigned by some efforts of trial and error. This process is iterated until all sectors have been analysed. As a result a cluster is identified as a group of sectors that are linked by maximum I/O flows for a given value of *k*. In our example the *t*-values, that here represent row-sums, are the following: $t_a = 100$; $t_b = 90$; $t_c = 80$; $t_d = 100$. Calculating the quotients of each sector's maximal forward value (bold numbers in the I/O table above) to its *t*-value yields: sector *a):* 40/100 = 0.4 ; sector *b):* 60/90 = 0.67 ; sector *c):* 40/80 = 0.5 ; sector *d):* 40/100 = 0.4. If the critical value *k*, was set to, say, *k* = 0.45, then sectors *a* and *d* would be discarded, because 0.45 > 0.4. One cluster would then be identified with its interdependent members *b* and c.

2.3.2. Simplifying I/O tables using a three-fold cut-off scheme

Hauknes et al. (1999) attempted to identify clusters of vertically linked industries such that inter-cluster flows are relatively small compared to intra-cluster flows. All sectors with their linkages found to be robust towards a certain algorithm are considered clusters. The algorithm constitutes a three-fold cut-off-schemes: *maximal link* (cut-off 1), *link strength* (cut-off 2*)* and *significant sector* (cut-off 3). Their objective is to remove weak inter-sectoral linkages and relatively unimportant sectors from the I/O table, respectively. Cut-off 1 discards all but sectors‘ maximal forward linkages from the table (*maximal link*). The next criteria used are a sector's intermediate sales as a percentage of the same sector's total intermediate sales (*link strength*) and a sector's intermediate sales as a percentage of all sectors‘ total intermediate sales (*significant sector*). The cut-off schemes are subject to

[27] The backward linkages method is the equivalent counterpart of the forward linkages method focussing on purchases instead of sales. Due to this analogy an explicit description of the former method is here neglected.

variations in order to identify sectors that are robust to these changes while at the same time searching for the highest amount of I/O linkages, thus unveiling a richer network structure.

Table 3 illustrates the reduction effect on the I/O table indicated by the amount of links and sectors when cut-offs are applied with changing criteria values and in different criteria combinations. ***1st step***: Only maximal forward ties are left in the table (cut-off 1). The amount of linkages and sectors reduces from 20,985 to 151 and from 156 to 151 respectively. ***2nd step***: The table is further reduced by all values that represent less than 15% of its sector's total deliveries (cut-off 1 and 2). The table now has only 107 links and 119 sectors. ***3rd step***: The first cut-off is abolished, that is, not only maximal but all linkage values are considered, and the second is retained (cut-off 2). As a result, the number of ties has risen strongly to 163, while only a few more sectors were added to a total of 125.

Table 3: Hauknes' three-fold cut-off scheme applied to an I/O table of Norway

Cut-Off Schemes	**Cut-Off 1**	**Cut-Off 2**	**Cut-Off 3**	**Links**	**Sectors**
Off-Diagonal Flows				20,985	156
1st step	yes	-	-	151	151
2nd step	yes	15%	-	107	119
3rd step	-	15%	-	163	125
4th step	-	10%	-	249	137
5th step	-	10%	1‰	185	108

Source: Hauknes (1999), p. 64.

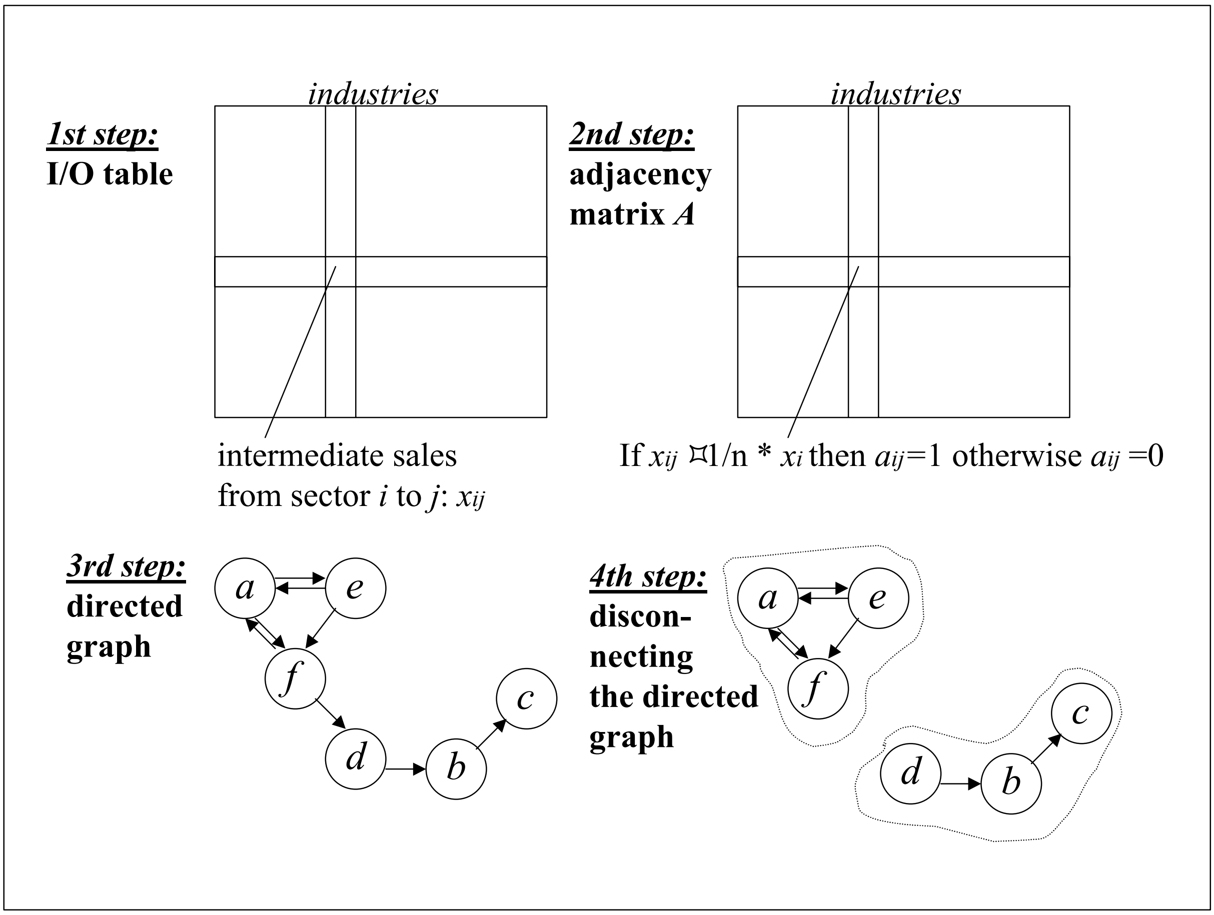
4th step: A further reduction of cut-off 2 to 10% increases links drastically to 249 and sectors to 137. The author concludes that most links are indeed weak and that with cut-off 2 going down, clusters tend to merge. ***5th step***: To exclude negligible flow values, cut-off 3 is used in combination with cut-off 2. This produces a table of 108 sectors with 185 links.

Comparing the results of the 5th step with those of the 2nd and 3rd steps shows a similar amount of sectors, but with a richer network structure. Thus, such a combination of cut-offs in a process of trial and error may help to find an "adequately" reduced I/O table that highlights groups of sectors with their linkages sufficiently large to be considered clusters.

2.3.3. Graph theoretic identification of clusters

Campbell (1963) identifies groups of industries that are interconnected by relatively important (vertical) forward and backward linkages in relation to links with sectors not belonging to the group. The method separates these groups from the overall structure of the industrial system using a two-fold cut-off scheme related to graph theoretic concepts. The essentials of the method can be explained in four basic steps (see Figure 4):

Figure 4: Graph theoretic identification of clusters



1st step: The I/O table *X* of intermediate sales of goods and services is taken as the point of departure.

2nd step: An adjacency matrix *A* is derived from the I/O table. Every cell x_{ij} in the I/O matrix that represents either a significant supply or demand link is given the value „1“ in the corresponding adjacency matrix cell a_{ij}, and „0“ otherwise. Significant links are - following a suggestion of Leontief (1965) – defined by the following cut-off criteria (*first* *cut-off*): $a_{ij} = 1$, if $x_{ij} \geq 1/n * x_i$, where *n* denotes the number of industries represented in the I/O matrix. Thus, a significant supply (demand) link exists, if a given sector *i* sells (buys) 1/*n*th or more of its total output (inputs) from (to) another industy *j*.[28]

3rd step: A directed graph (digraph) is constructed derived from the adjacency matrix *A*. Arcs, constructed for every „1"-cell in *A*, represent flows of goods and services between industries. The latter are indicated using abbreviations or numbers at the respective ends of the arcs. The arrow indicates the direction of flows.

4th step: All arcs are removed that would disconnect the digraph from its „central portion" reducing that core to a minimum size (*second cut-off*).[29] The remaining subgraphs - termed *articulation components* - are thus groups of industries (clusters) that have strong links to other sectors of the group relative to ties with outside industries.

2.3.4. Comparing sales and procurement profiles

Czamanski (1974), Roepke et al. (1974) as well as Feser and Bergman (2000) presented a tool for the recognition of industrial groupings that show a high degree of similarity of I/O transaction profiles, thus focussing on indirect linkages between sectors. Two sectors may not have any direct transactions. However, they may have transactions with a common to both third sector. In that case the two sectors are said to be indirectly linked via the third sector. In Figure 5 the four types of indirect linkages are illustrated.

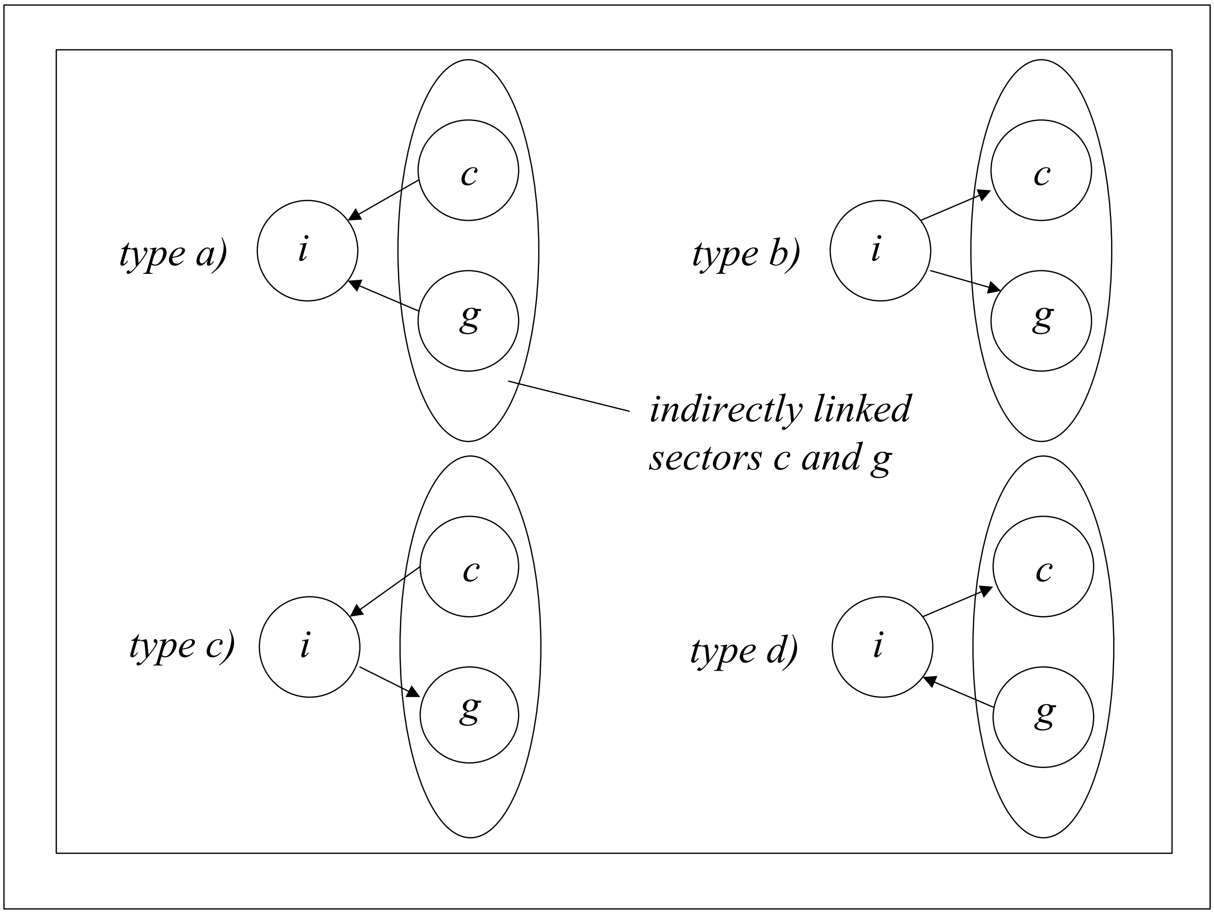
Sectors *c* and *g* are indirectly linked, because buyers / suppliers of *c* may also be buyers / suppliers of *g* (*type a) / type b)*). And the buyers of *c* may be suppliers of *g* (*type c)*) or vice versa (*type d)*). Czamanski (1974), Roepke et al. (1974) as well as Feser and Bergman

[28] "For example, industry 3 sells more than \$5.0 million worth (1/27 of \$134.1 million) of its output to industry 6. For this reason, the cell in row 3, column 6 receives an entry of 1, representing a demand link. Similarly, industry 3 purchases more than \$5.0 million worth (1/27 of \$134.1 million) of its inputs from industry 11. The cell in row 11, column 3 receives an entry of 1, representing a supply link. [...] These measures possess an advantage as possible simplification criteria because the cutoff levels involved are developed relative to the output level of each industry in question, rather than depending upon an arbitrarily established level for all industries. Thus, the cutoff for identifying significant linkages will increase or decrease as the total output level for each industry increases or decreases" (Campell, J. (1975), p. 97).

[29] See Campbell, J. (1975), p. 104.

(2000) applied factor analysis,[30] a multivariate technique that groups sectors that have similar variations in their shares of transaction volumes over all partnering sectors.

Figure 5: Four types of indirect linkages between sectors



The procedure may be explained in four steps (see Figure 6):

1st step: An I/O matrix representing inter-sectoral transactions of intermediate goods and services is taken. *2nd step*: From this I/O table a matrix of technical coefficients is derived. Technical coefficients are computed for every sectoral pair. They describe the relative importance of linkages for either the supplying (*a*) or the receiving sector (*b*):

$$a_{ij} = x_{ij} \Big/ \sum_j x_{ij}\,; \qquad a_{ji} = x_{ji} \Big/ \sum_i x_{ji}\,;$$

$$b_{ij} = x_{ij} \Big/ \sum_i x_{ij}\,; \qquad b_{ji} = x_{ji} \Big/ \sum_j x_{ji}\,.$$

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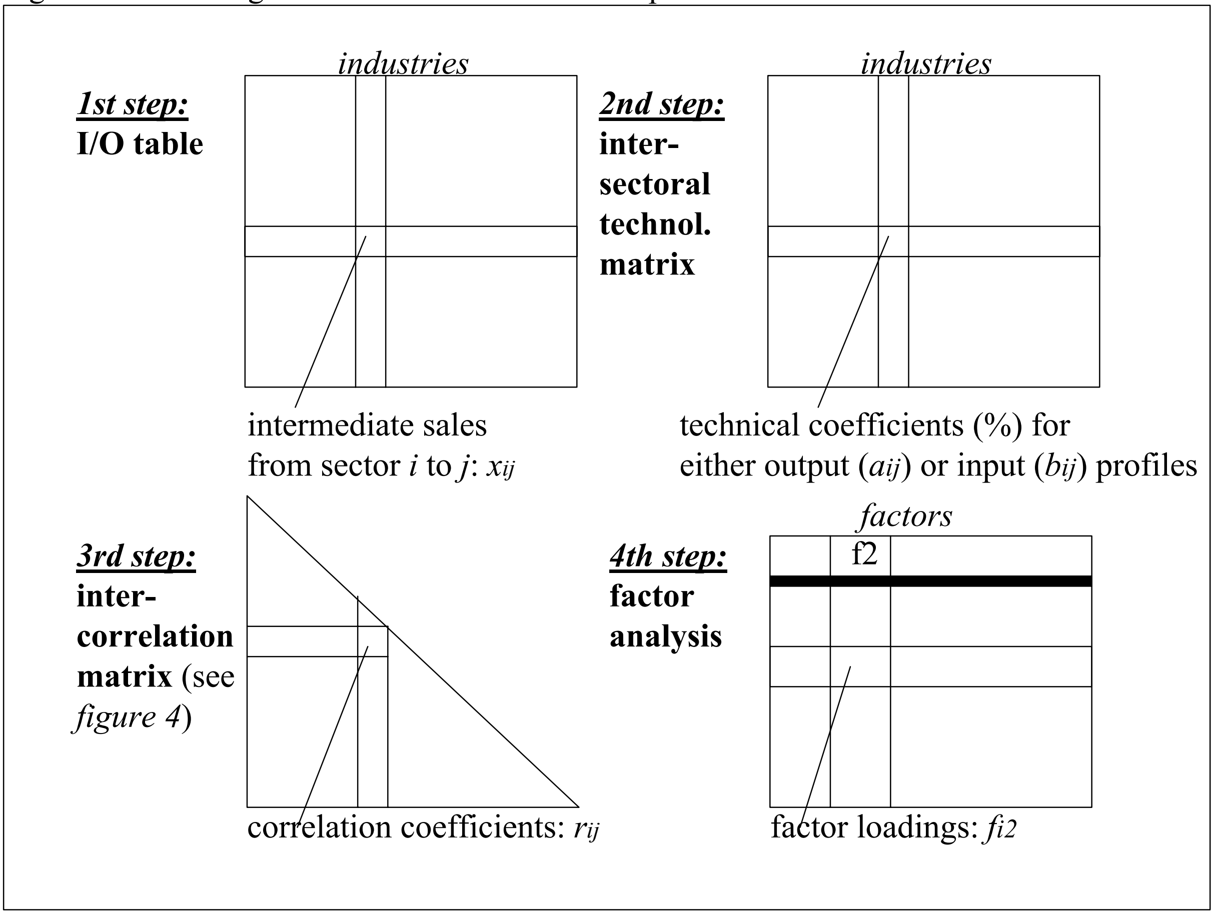
[30] The reader is referred to Hair, J.F. Junior (1998) for a description of the technical details of factor analysis.
[30] While Roepke et al. (1974) only considered the first two correlation coefficients, Czamanski (1974) and Feser & Bergman (2000) analyzed all four types of indirect linkages. In addition, Roepke et al. (1974) applied factor analysis with the use of a symmetric I/O matrix. The latter is derived by simply adding the

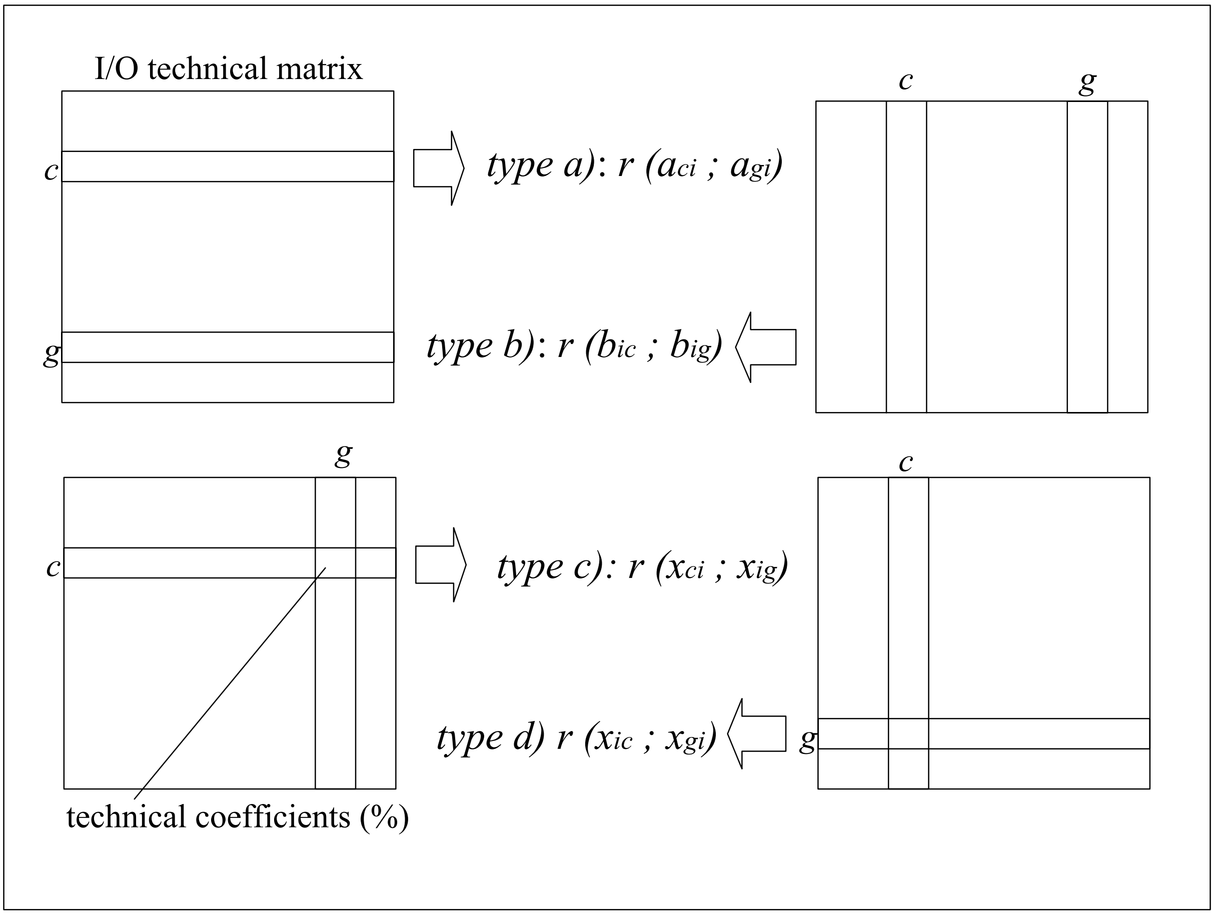
Here x_{ij} denotes yearly values of flows of goods and services from industry *i* to industry *j*, $\sum_j x_{ij}$ total output of industry *i* and $\sum_i x_{ij}$ total inputs bought by industry *j*.

Figure 6: Measuring similarities in industries' I/O profiles



3rd step: A symmetric intercorrelation matrix *R* is set up. Its elements are correlation coefficients, which describe the similarity between two sectors' I/O profiles, indicating the extent to which two sectors are indirectly linked. Since there are four types of indirect linkages (see Figure 5) there are also four correlation coefficients (see Figure 7), each representing one type of indirect linkage: $r(a_{ci};a_{gi})$; $r(b_{ic};b_{ig})$; $r(a_{ci};b_{ig})$; $r(b_{ic};a_{gi})$ for industries *i* = (1.., *c*,..., *g*,.., *n*). A high value of the first and the second coefficient signifies that industries *c* and *g* have a similar sales and procurement profile respectively (types *a)* and *b)* in Figure 5, Figure 6 and Figure 7). A high value of the third coefficient indicates that suppliers of inputs purchased by *g* are users of the products sold by *c* and vice versa for the fourth coefficient (types *c)* and *d)* in Figure 5, Figure 6 and Figure 7).[31] Czamanski (1974) suggested to select the highest of the four correlation coefficients for each industry pair in order to set up the intercorrelation matrix. All industries were removed from the matrix that had either a null column or null row vectors.

Figure 7: Correlation coefficients to measure for four types of indirect linkages



4th step: Factor analysis was run on the basis of the intercorrelation matrix with factor loadings representing the extent to which sectors are assigned to factors. All sectors with high loadings on a specific factor have in common similar I/O transaction profiles as an indicator for indirect linkages. This group of sectors is then interpreted as clusters.

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values in the I/O matrix cells that are symmetric: $b_{ij} = x_{ij} + x_{ji}$, where x_{ij} and x_{ji} are elements of a matrix of I/O technical coefficients. This approach provides no indication of the direction of flows.

2.4. The empirical literature on the driving forces of agglomeration

In the above section we have sketched I/O techniques for cluster identification. We have seen that these methods capture only one of many relevant types of linkages that may generate agglomeration forces. Moreover, I/O results provide no indication as to whether or not these linkages give in fact rise to agglomeration forces. We will therefore now investigate what other strands of analysis have contributed to the understanding of what the driving forces in clusters are.

The most prominent research confined to this issue is found in the new growth literature. Although scholars have provided several specific theoretical arguments for the causes of clustering (see Figure 2 in section 2.1.2), one type of externality, namely that related to knowledge, has found increased attention ever since Romer (1986) and Lucas (1988) have argued that it is the 'engine of growth'.

2.4.1. The role of knowledge externalities

While Jaffe (1986, 1989), Acs et al. (1992), and Feldman (1994) have shown that investments in R&D by private enterprises as well as universities may "spill-over" to third-party firms,[32] Jaffe et al. (1993) have provided some evidence that the extent to which knowledge spills over may be dependent on the spatial distance from the knowledge sources. The method they apply is that of tracing back the "paper trails" of knowledge diffusion by linking the location of inventors, as indicated by patent data, and the locations of patent citations. The latter represents a piece of previously existing knowledge that has been relevant for the development of the patented invention. The authors explained that patents contain geographic information about both the inventor and the technological antecendents of the invention. It is on the basis of such U.S. patent data for the years 1975 and 1980 that the authors analyse the frequency with which citations come from the same country, the same state and the same metropolitan area as originating patents. Because localization of citations may not necessarily be the result of knowledge spillovers, but may also stem from a pre-existing geographic co-location of firms in technologically related activities, control frequencies were calculated. The latter refer to citation-patent pairs that are not directly related, as is documented by the originating patent data, but that are proximate in technological space, that is they are assigned to the same patent class. Next, the two types of frequencies were compared. This has shown that the frequency with which citations to U.S. patents match the originating patents geographically are indeed significantly greater than a control frequency that is designed to capture the preexisting geographic distribution of technologically related activities. These effects are particularly significant at the local (SMSA) level.

Audretsch, D. and Feldman, M. (1996) have argued that if geography matters for the extent to which knowledge diffuses, spatial concentration of innovative activity can be observed. They provide some evidence in favor of this hypothesis, by calculating locational Gini coefficients using innovation counts that are assigned to U.S. 4-digit SIC sectors as well as to U.S. states. Furthermore, Ginis were computed using both industries' value added as well as employment in order to describe the degree to which economic activity is clustered in space. Results suggest that the bulk of U.S. innovative activities can be found either in California or in New England, while all other regions are not particularly innovative. And they show that industries that exhibit the greatest geographic concentration of manufacturing activity are not identical with the industries that show the highest propensity for their innovative activities to cluster in space. Next, their aim was to explain the propensity for U.S. innovative as well as economic activity to cluster geographically, by linking this geographic concentration to the existence of knowledge spillovers. The latter were captured by measures for the importance of industry R&D expenditures in relation to sales, university R&D that is relevant to the industry in question as well as the industry's employment share of skilled labor. Their findings show that certain industries' economic activities tend to cluster in geographic space due to the importance that is placed on markets of skilled labor as well as on the same industry's R&D. And, even after controlling for the extent to which industries' production is spatially concentrated, the three knowledge-generating determinants were still found to have a significant impact on the propensity for these industries' innovative activities to cluster in geographic space.

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[32] Griliches (1979) surveys the empirical literature on the role of knowledge spillovers in generating growth.

2.4.2. Marshall-Arrow-Romer externalities versus Jacobs externalities

Taking on the results of Audretsch and Feldman (1996) that have suggested that knowledge spillovers may have an impact on clustering, it arguably is a relevant task to analyse the importance of different types of externalities. The literature on new growth economics has distinguished between two types of knowledge externalities.

The first type is called MAR externalities (Marshall (1920) – Arrow (1962) – Romer (1986, 1990)) and refers to learning of firms from other local firms in the same industry. Firms may accumulate knowledge that spills over from other both geographically as well as technologically proximate firms. Therefore, firms may benefit from the degree to which a region is specialized in a specific industry and may thus grow faster.

The second type refers to effects of knowledge spillovers that occur between firms of different but complementary industries. These effects are called Jacobs (1969) externalities. These benefits stem from the variety or diversity of local industries.

A similar distinction can be found in a non-dynamic context to explain why clusters and cities form. It has been introduced in the urban economics literature by Lösch (1954) and Isard (1956). They have termed externalities that arise from co-location of firms within the same industry *localization economies*, while the effects resulting from the co-location of firms of different industries in the same area or city habe been termed *urbanization economies*.

Whether diversity or specialization of economic activity better promotes growth in cities has been debated especially by Glaeser et al. (1992), Henderson et al. (1995) and Feldman and Audretsch (1999).

Glaeser et al. (1992) used a data set on the geographic concentration and competition of the six largest two-digit industries in 170 of the largest U.S. cities to investigate which industries in which cities have grown fastest between 1956 and 1987. Moreover they attempted to explain why. In their estimation equation the dependent variable was the logarithm of employment in 1987 divided by employment in 1956 in the city-industry. To measure the variety of industries in the city outside the industry in question they used the fraction of the city's employment that the largest five industries other than the industry in question account for in 1956. The prediction of Jacobs is that the lower this ratio, the more diverse the city is and the faster the industry in question should grow. The measure used for the MAR argument was the fraction of the city's employment that this industry represents in that city, relative to the share of the whole industry in national employment. This variable reflects the degree to which a city is specialized in a particular industry relative to the degree of economic activity in that industry that would occur if employment in the industry were randomly distributed across the U.S. Hence, a positive MAR coefficient would indicate that increased specialization within a city is conducive to higher city-industry employment growth. Additionally, they tested an argument of Porter (1990). He has insisted that it is local competitive pressure that fosters the pursuit and rapid adoption of innovation, because the alternative to advancing technologically is demise (see section 2.1.2.2). The measure of local competition of an industry in a city was the number of firms per worker in this industry in this city relative to the number of firms per worker in this industry in the U.S. According to Porter the analysts would expect that the higher this quotient is the higher employment growth in an industry in a city will be. Their findings show that local competition and urban variety, but not regional specialization, determine employment growth in industries in cities. Thus, these findings are consistent with Jacobs and Porter, but not with the MAR argument. However, limitations to the data do not allow for any definitive conclusion. Particularly, it has been criticised that the analysis is confined to a specific period in the history of U.S. industries, which is not necessarily representative for a longer time-span.

In contrast to the above-sketched analysis Henderson et al. (1995) argued that externalities may have different patterns in different stages of product development. Hence, they have suggested to distinguish between newer and older industries. They used employment data for five traditional two-digit capital goods industries and three newer two-digit manufacturing industries (computers, electronic components, and medical equipment) in the entire available sample of 224 metropolitan areas in 1970 and 1987. The MAR measure is the ratio of own industry employment to total local civilian employment in 1970 among other. The Jacobs measure is, among other, a Hirschman-Herfindahl index for city *i* for two-digit industry *k* that was computed for about 50 three-digit manufacturing industries:

$$HHI_{ik} = \sum_{j \notin k} s_{ij}^2 \ ,$$

The share in city *i* of industry *j* is denoted s_{ij}. If employment in 50 industries, excluding the sector in question, is concentrated in one other sector, HHI_{ik} takes on a value of one. In contrast, if employment was evenly distributed over industries, HHI_{ik} has a value of 0.02.

Results for the traditional industries suggested that employment growth is higher in cities where the degree to which past employment concentrations in the own industry is high (MAR). In contrast, the Jacobs measure seems to be less important, as for no traditional industry, but one, significant effects could be measured. Estimates for the newer industries suggested that both Jacobs and MAR externalities play a significant role. Although Henderson et al. (1995) experimented with the same specification as Glaeser et al. (1992), their findings do not necessarily confirm estimation results of the latter, though the samples and time periods differ.

Feldman and Audretsch (1999) have taken on the same issue, but in contrast to previous studies they estimated a model in which the dependent variable is the number of innovations in 1982 assigned to a specific four-digit SIC industry in a particular city (Standard Metroplitan Area) in the U.S., rather than employment growth. The advantage of this approach is that, if it is that knowledge externalities play an important role in generating growth, as was stressed by Romer (1986) and Lucas (1988), then they should primarily manifest themselves on firms‘ innovative performance.[33] Feldman and Audretsch (1999) have used the same MAR measure and local competition measure as was used in Glaeser et al. (1992). However, the diversity measure is somewhat differently constructed. In contrast to the above-sketched studies, in which it was assumed that all industries are equally close in technological space, Feldman and Audretsch considered a measure of complementarity between sectors. They systematically identify six science-based industry clusters comprising industries that have a common underlying science and technology base and are thus considered complementary and close in technological space. This cluster formation is based on the results of a survey among R&D managers that assess the relevance of basic scientific research in various technological fields to the industries they represent. The diversity measure is defined as the share of total city employment accounted

[33] See Baptista and Swann (1998), p. 529.

for by employment in the city in industries sharing the science base, divided by the share of total U.S. employment accounted for by employment in that same science base. The Jacobs prediction is that of a positive coefficient of science-based related industries. This would indicate that the presence of complementary industries is conducive to greater innovation performance of firms. The empirical results of this study provide an additional argument in favour of the Jacobs‘ diversity thesis. Results suggest that specialization of economic activities does not promote innovative output, while diversity across complementary economic activities sharing a common science base does. Moreover, they provide some evidence that the degree to which local firms compete is more conducive to innovation than is local monopoly.

Baptista and Swann (1998) have set out to analyse a slightly different research question. They primarily asked whether firms in strong geographical clusters or regions (as measured by regional own-sector employment) are more likely to innovate than firms outside these regions. However, they also addressed some of the questions that stand in the tradition of the above described investigations. Their analysis differs from the latter studies in the following aspects, among other. First, regions are considered, rather than cities or metropolitan areas only. Second, instead of using a specialisation measure that would relate the proportion of sector employment in the region's total employment to the national equivalent, they employ an absolute value of sector employment in a region to meaure the strength of a cluster. This has arguably the advantage that it does not "*ignore the fact that a region might make for a strong cluster in a certain industry, even if this industry is not important in the region's overall breadth of activities*".[34] This distinction reflects the research question that, in contrast to the before mentioned analysis, does not primarily focus on the diversity-specialisation issue. Third, a five firm three digit industry concentration ratio by sales was included to the estimation, which may be interpreted as a measure for local competition. The authors acknowledge that other measures may be better ones, such as the number of workers per firm in the region for each industry, for instance. As a measure for industry diversity in regions a simple Hirschman-Herfindahl index was computed for employment in all manufacturing SIC sectors, following Henderson (1994) and Henderson et al. (1995) (see above).

[34] Baptista and Swann (1998), p. 530.

The data base they use is a combination of a panel innovation count data set for 248 firms over the period 1975-1982 and data on industry employment for 11 CSO standard regions in Great Britain and Northern Ireland over the same sample period.[35] Firms were assigned to the two-digit SIC industries, for which regional employment data on an equivalent level of aggregation was available. Their estimation results suggest that the stronger clusters are, that is the larger own-sector employment is, the more likely it is that a firm located in that cluster (region) would innovate. Moreover, firms that are exposed to intense local competition are more likely to innovate, as evidenced by a negative market concentration coefficient. And the coefficient of the diversity measure is not significant. Thus, results do not indicate that Jacobs externalities are not operating.

There have been similar investigations to that of Baptista and Swann (1998). Specifically, the following contributions are worth mentioning: Beaudry, C. (2001), Beaudry, C. and Breschi, S. (2000) as well as Beaudry, C. and Swann, P. (2001).

We have reported on the literature that is concerned with the issue of whether local industrial diversity, specialisation or cluster strength drives local growth. We have seen that the measures used to capture inter- or intra-industrial externalities are based on rather crude sectoral employment data. Therefore, they cannot provide deeper insights into the true causes of agglomeration forces, whether it is knowledge spillovers, labor market pooling effects, access to input and output markets, competition or other. We will now turn to a first investigation that considers the three Marshallian forces more specifically.

[35] Central Statistical Office (CSO).

2.4.3. The relative importance of the three Marshallian forces

Dumais, Ellison and Glaesor (1997) have investigated the impact of each of the three Marshallian forces on employment growth in 51 states, as measured by firm births in 134 three-digit SIC manufacturing industries (see section 2.1.2.1).[36] They used the U.S. Census Bureau's Longitudinal Research Database (LRD). It provides information about either firm births, which are an outcome of 'true entrepreneurial work' without the support of a mother company ("new firm birth"), or the creation of establishments that are owned by a firm that had establishments in previous censuses ("old firm birth"). Additionally, it offers information about plant closures among other. For their estimation they pooled the data of five time-intervals: 1972-1977, 1977-1982, 1982-1987 and 1987-1992. It is reported that new firm births make for an average of 87% of all newly-established plants in these five-year intervals, which accounts for about 50% of employment growth due to firm births.

The dependent variable is $\log(1+\Delta E_{ist}^{j})$. It indicates the change in sector *i*'s employment in the state s between time *t* and *t+1* due to events of type *j* (either new or old firm birth).

The explanatory variables are defined as follows. The measures used for input supplier presence (*Input*) and product customer presence (*Output*) for industry *i* in the geographical unit *s* at time *t* are

$$Input_{ist} \equiv \sum_{j \neq i} I_{ji} \frac{E_{jst}}{E_{jt}} \quad \text{and}$$

$$Output_{ist} \equiv \sum_{j \neq i} O_{ji} \frac{E_{jst}}{E_{jt}},$$

where I_{ji} denotes the share of industry *i*'s inputs procured from industry *j*, O_{ji} is the share of sector *i*'s outputs shipped to industry *j*, E_{jst} is sector *j*'s employment in geographical unit *s*, and E_{st} is total employment in location *s*. If no input supplying or output purchasing industries are in that geographical unit the measures take on a value of zero. It is equal to one if all of them are located in that location. The prerequisite data were taken from the

National Industry-Occupation Employment Matrix for 1987, which accounts for 277 occupations and 185 industries, including 51 manufacturing sectors.

The authors aimed at capturing labor market pooling effects by using the following measure for the suitability of the labor mix in an area:

$$LaborMix_{ist} \equiv -\sum_{o}\left(L_{io} - \sum_{j \neq i}\frac{E_{jst}}{E_{st} - E_{ist}}L_{jo}\right)^2,$$

where o indicates occupations and L_{io} denotes the fraction of sector i's employment in occupation o. The right hand term within brackets is interpreted as an estimate of the composition of the location's labor force obtained by taking a weighted average of the typical employment patterns of the other manufacturing sectors located there. This term is being subtracted from L_{io}, which is a proxy for the occupation mix desired by industry i. Hence the full term is designed to indicate the extent to which the existing local occupation mix in other industries matches the desired occupation mix by industry i. Due to the scaling of the variable better matches correspond to higher values.

In order to assess risk pooling effects (see section 2.1.2.1) this variable was regressed both on employment changes due to firm births as well as employment losses due to closures ($\Delta E_{ist}^{closures} / E_{it}$). This is regarded as a proxy for risk in the industry.

Knowledge spillovers were supposed to be reflected by the following measure:

$$Techflow_{ist} \equiv \sum_{j \neq i} T_{ji}\frac{E_{jst}}{E_{jt}},$$

where T_{ji} indicates technology flows from industry j to sector i. In total, the term is assumed to reflect the spillover benefits that a firm in industry i receives when locating in

[36] The only other study found that investigates the issue of relative importance of agglomeration forces is that of Peri and Cunat (2001). They have used data for Italian regions and they employ measures for the three Marshallian forces very similar to those proposed by Dumais, Ellison and Glaeser (1997).

state *s*. The data for this variable has been taken from an inter-industrial technology flow matrix constructed by Scherer (1984) on the basis of R&D and patent statistics.

Additionally, to capture the extent of knowledge spillovers that are due to co-ownership of plants across industries, a co-ownership matrix W_{ji} was set up using the LRD data base. It indicates to what extent plants in sector *i* are integrated with plants in industry *j*. Using this data an *Integration*-measure was designed that shows to what extent an area *s* has a lot of activity in industries which may provide knowledge spillovers to firms in industry *i*:

$$Integration_{ist} \equiv \sum_{j \neq i} W_{ji} \frac{E_{jst}}{E_{jt}}.$$ [37]

Various specifications were used in estimating the relationship between locations' employment changes and the three agglomeration forces. However, we will here focus on reporting the results of the log specification, which are most consistent.

They provide very strong evidence in favor of the labor market pooling argument. While input supplier and customer presence seems to be relatively unimportant in explaining firm births, knowledge spillovers tend to be more important.

The *LaborMix* variable is highly significant and shows the expected sign. The effects are stronger in generating new firm births than old firm births. Moreover, labor market pooling effects seem to be stronger in industries with high closure rates. This confirms the Marshallian hypothesis that risk pooling can be an advantage to local industries.

The *Input* variable is not significant with respect to new firm births, but appears to be important in explaining the location of old firm births. In contrast, the *Output* variable is more important in explaining where new firm births are located compared to the effects on old firm births. In all of these cases coefficients are fairly small.

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[37] Additionally, this variable has been interacted in estimation regressions with a variable College, which equals the fraction of employment in industry i that is part of occupations requiring a college degree. This accountrs for the fact that knowledge, in the form of human capital, may also be transferred via labor markets (see Dumais, Ellison and Glaeser (1997) Appendix B).

Knowledge spillovers captured by the *Integration* variable are significant in generating new firm births. These effects are even stronger with respect to old firm births as well as to industries which employ more workers with college degrees. The *TechFlow* measure is highly significant, but the coefficient is small in size.

2.5. Cluster case studies

All of the techniques sketched in sections 2.2 and 2.3 have been 'top-down' approaches, which have been suggested by scholars to identify many clusters. However, none of these methods can be used to identify a specific cluster. We will therefore now review two exemplary case studies, to analyse how their authors have proceeded to identify and describe specific clusters.[38] We will begin by the study of Saxenian (1994), which has been an essentially qualitative anecdotal-type of study. Then we review a quantitative case study, conducted by Sivitanidou (1999).

2.5.1. The qualitative case study of Saxenian

Saxenian (1994) compared two of the most spectacular phenomena of geographic concentration of industries, Northern California's Silicon Valley and Boston's Route 128. Both have become known as highly innovative and world leading centers in electronics ever since the 1970s. She observed that the performance of these two regional economies have diverged in the 1980s. While Route 128 has reportedly lost ground to international competitors as well as to the Silicon Valley, the latter has successfully adapted to an increasingly intense international competition. Saxenian has set out to understand why this has happened. Obviously, the fact that firms in both regions are spatially proximate cannot explain, why they have performed differently.

Various types of empirical material, both from interviews as well as from a variety of public and private data bases, industry and trade press, and from corporate documents,

[38] Recently, there have been numerous cluster case studies: Hall and Markusen (eds.) (1985), Steiner (ed.) (1998), Oakey (2000), Keeble et al. (1999), Wever and Stam (1999) as well as Sternberg and Tamásy (1999), just to name a few. Moreover, Nadvi, K. and Schmitz, H. (eds.) (1999) have edited a special issue of *World Development* on clusters in developing countries, comprising additional case studies.

were collected.[39] Employment data, taken from the U.S. Bureau of the Census, was used to compare the growth between the two regions. Any other data sources that allow for more specific information, such as for instance number of establishments by employment class size as well as performance indicators, like profitability or output, had the drawback that the data were assigned to the location of firms‘ headquarters, rather than plants. Or firm-level information has only been published for a group of publicly traded firms. However, many firms in these two regions have been non-publicly traded enterprises. While these data sources may be informative to studies of a single cluster, they could only be used with some limits for this comparative analysis of regions. Hence, this book's arguments rest primarily on interviews with firm representatives. But these numbered a respectable 160 or more, of which the majority have been conducted between 1988 and 1991.

While Saxenian‘s research interest has primarily been to describe the two clusters in ways in which they differ thereby detecting some of the causes of their differing performance, the clusters have been identified by some ad-hoc manner. The author used data for the following high technology industries in order to determine their functional boundaries: Computer and Office Equipment (SIC 357), Communications Equipment (SIC 366), Electronic Components and Accessories (SIC 367), Guided Missiles and Space Vehicles and Parts (SIC 376), Instruments (SIC 38), and Computer Programming and Data Processing (SIC 737).[40]

The geographical boundaries of the clusters were defined by either four state counties or three-digit telephone code areas depending on the data bases used.[41] Silicon Valley's boundaries were determined by Californian counties Santa Clara, San Mateo, Alameda, and Santa Cruz or telephone code areas 408, 415, or 510. Route 128 refers to Massachusetts counties Middlesex, Suffolk, Norfolk, and Essex or firms headquartered in the telephone ares 617 or 508.

She argued that it is helpful to compare the two regions‘ industrial systems along three dimensions: local institutions and culture, industrial structure, and corporate organization.

[39] See Saxenian (1994), p. 209.
[40] See Saxenian (1994), p. 209.
[41] See Saxenian (1994), p. 211.

These dimensions are interdependent. They “*tend, in practice, to become mutually reinforcing components in coherent regional economies*“.[42]

The two *local* educational and research *institutions*, Stanford University and the Massachusetts Institute of Technology (MIT), that, in principle, take on similar functions as sources of knowledge, have had a different economic impact in their regional economies. In contrast to MIT, Stanford University has arguably been far more active in promoting the diffusion of knowledge in the regional economy by, for instance, supporting spin-offs and technology start-ups in the region.[43]

Moreover, the provision of risk capital by business-angels in Silicon Valley has aruably been an advantage over Route 128 where financial institutions have tended to be rather cautious, formal and slow.[44]

Silicon Valley firms had a *culture* that promoted open exchange and informal cooperation. In contrast, Boston’s Route 128 has cultivated “*practices of secrecy and corporate loyalty* [that] *govern relations between firms and their customers, suppliers, and competitors, reinforcing a regional culture that encourages stability and self-reliance*“.[45]

Silicon Valley was characterized as a fragmanted network-based *industrial structure* of firms that specialize and that engage in relations with other specialists. Geographic proximity enhances frequent interaction, which sustains the network through the development of trust between firms. In contrast, Route 128 was described as an independent firm-based system of large vertically integrated corporations that tend to internalize resources.[46]

Internal *corporate organization* in Silicon Valley has reportedly been highly decentralized. Firms activities have been horizontally coordinated, with a high degree of professional autonomy and a strong emphasis on team work, which has blurred the traditional

[42] Saxenian (1994), p. 8.
[43] See Saxenian (1994), p. 8.
[44] See Saxenian (1994), p. 64.
[45] Saxenian (1994), p. 3.
[46] See Saxenian (1994), p. 161.

boundaries of corporate functions within the firms.[47] Corporations in Boston's Route 128, in contrast, have a reportedly high degree of centralization and hierarchical coordination, with formal flows of information. This organizational structure is said to be "*separate and self-sufficient*".[48]

In the conclusion, Silicon Valley's network-based structure of firms that have each been organised in a decentralized manner paired with the region's institutions and culture that enhances knowledge diffusion has arguably favored their superior capacity to adapt to fast changing competitive patterns and have thus been key determinants of its economic growth. In contrast to many other studies in the Urban and Regional science literature,[49] she has not only investigated the manner in which co-located firms interact, but she has also looked inside the firm. Specifically, she has shown that the capacity to generate as well as to exploit agglomeration advantages does not only depend on what other firms as well as institutions are located nearby. A critical success factor can also be the corporate organisation, in which the incentives for individual employees and project teams to interact with other firms are embedded.

2.5.2. The quantitative case study of Sivitanidou

The study of Sivitanidou (1999) had two research tasks, wich focused on the spatial preferences of computer software firms located in Southern California. First, it was analysed what the perceived relative importance of location attributes is. Second, Sivitanidou related the preferences for such attributes with the general firm profile (e.g. organisational structure, size of operations, age) as well as with their functional traits (e.g. core functions, outsourced activities, markets served). The study area was confined to Southern California ranging from San Diego in the Southeast to Santa Barbara in the Northwest and San Bernadino in the Northeast.

[47] See Saxenian (1994), p. 50.
[48] Saxenian (1994), p. 161.
[49] See Saxenian (1994), p. 3.

Given the absence of published secondary data, this study used direct survey data. From a mailing list of over 3,000 software companies a sample of 120 firms had returned questionnaires with valid responses.

The authors had no direct knowledge as to what extent the general profile of the sample firms is consistent with that of the total population of relevant firms. However, they compared it with anecdotal accounts and existing empirical literature, which speaks in favor of a representative sample.[50] Moreover, a mapping excercise revealed that the spatial distribution of firm locations parallels that of software firms registered at the California Manufacturers Association (1996).

The majority of 91% of the sample firms did not represent parts of corporate entities. They were on average as young as 10 years and the majority of almost 80% had less than 25 workers. The majority of almost 90% of the sample enterprises focussed on the development of software innovations, of which most ideas stemed from company workers and clients rather than from other firms‘ workers or academia. Most of them serve primarily domestic markets that have been characterized by ‘Government‘, ‘Professional Services‘ and ‘Manufacturing‘. Each of these market segments provided a customer base for about 40-45% of the sample firms. These firms employ highly skilled workers. Almost 80% of the sample firms‘ employees had on average a four-year college degree, master’s degree or doctoral degree.[51]

Concerning the methodology company executives had been asked to assign ratings, ranging from 1 (lowest) to 5 (highest), a selection of location attributes. Next, these preferences were related to company traits by econometric analysis.

The most highly rated location attribute was the access to skilled labor. 64% of the sample firms considered it either very important (rating = 5) or important (rating = 4) for the firm’s success. Other factors that had on average been regarded as important were the following, stated in the order of relevance: access to a good environmental quality, low

[50] See Sivitanidou (1999), pp. 116-118.
[51] See Sivitanidou (1999), p. 116.

crime districts, regional/international airports, freeways and domestic clients, other high tech firms, universities, urban/residential amenities and high-quality districts.[52]

The findings of the econometric analysis has suggested that company profiles as well as functional traits matter.[53] Single-unit independent or single-unit companies tend to have higher preferences for spatial access to markets of qualified labor. Younger firms have higher preferences for access to other high technology firms and clients. Companies that place more importance on software development show higher preferences for access to labor, other high technology firms and universities. Firms outsourcing client-related functions express higher preferences for access to other high technology firms. And lastly, firms that tend to use various forms of telecommunications (telephone, Internet and video-conferencing) as an alternative to face-to-face contacts show lower preferences for access to other firms, airports and freeways.

While findings of this type of study can suggest hands-on policy implications for groups of firms analysed in the sample, they do not reveal to what extent agglomeration externalities exist. Thus, they do not provide any knowledge with respect to market failures, which could indicate a justification for public intervention. One possible way to assess possible productivity, profitability or innovation performance benefits due to firms' locating in clustered sites could be to relate these Likert-scale preferences to some performance indicators. We will come back to these considerations in section 3.1.

2.6. Summary

In this chapter we have seen that neither a standard definition nor a standard method of cluster identification exists. After reviewing the various cluster definitions provided in the literature we have seen that two main cluster dimensions are common to most definitions, namely a *geographical* and a *functional dimension*. Firms in clusters are concentrated in geographic space. Proximity enables frequent face-to-face contacts between firms (*geographical dimension*). And cluster firms have a higher performance relative to spatially dispersed firms due to various types of inter-firm linkages that generate

[52] See Sivitanidou (1999), p. 120.
[53] See Sivitanidou (1999), p. 145.

agglomeration forces (*functional dimension*). Unfortunately, the cluster notion remains sloppy in expression and does not provide a starting point for rigorous cluster identification excercises. Specifically, we do not have a full understanding of the spatial scope of clusters and where the spatial boundaries of clusters are.

The two main strands of the cluster identification literature have been reviewed, each focussing on one of the two cluster dimensions. One line of inquiery has focussed on employment data, thereby investigating to what extent firms of either one or many industries are spatially proximate. The other strand has investigated to what extent industries are inter-linked by relevant I/O flows.

However, these methods of cluster identification have several defects. First, I/O methods proposed by Roelandt et al. (1997), Hauknes et al. (1999) and Campbell (1975) are rather *arbitrary*. They employ cut-off schemes that solely depend on an individual judgement of the analyst. Thus, two researchers would not necessarily identify the same cluster when employing such a method. Hence, these studies should not be used for comparative cluster studies. Moreover, in all the methods used the spatial scope of clusters has been determined exogenously. The implicit assumption that the geographical boundaries of clusters are identical to those of political regions is rather contestable.

Second, none of the methods sketched above are *complete and theoretically consistent*, in the sense that all essential features of clusters are captured according to theoretical considerations. Only few studies have tried to combine an assessment of the geographic dimension with that of the functional dimension. Czamanski (1977), Streit (1969) and Richter (1969) have gone into the right direction by combining an analysis of spatial association of industries with I/O analysis (see Table 1, p. 22). However, I/O analysis only captures one of many relevant types of inter-firm linkages that may generate agglomeration forces. Moreover, they lack any information about whether the identified clusters are spatially concentrated.

Third, none of these studies is *operable* in the sense that the results of the cluster identification excercises provide starting points for public policy. They do not explain which agglomeration externalities are in fact generated and exploited within each cluster.

Hence, practioners do not know whether or not there are market failures, which may indicate a justification for public intervention.

This issue of agglomeration forces has been analysed foremost by empirical researchers in the field of new growth theory. They have provided some insights on the extent to which either aggregate effects of these forces or, more specifically, knowledge spillovers and local competition determine cluster growth. Less attention has been guided to the issue of the relative importance of each of the specific forces.

From a methodological stance we have learned from these studies that a reasonable way of quantifying agglomeration forces is to relate indicators for its sources with firm performance measures and to apply econometric techniques.

All of the studies reviewed here have used 'top-down' approaches, with their research area spanning many sub-national regions. They have aimed at either identifying various clusters in the national economy or analysing agglomeration forces with a 'bird's eye view'. So far no method has yet been developed to identify a specific cluster.

There have also been various 'bottom-up' cluster case studies, which offer far more detailed results with respect to the individual cluster compared to the 'top-down' approaches mentioned above. However, they have primarily attempted to describe certain features in the cluster. Hardly any importance has been put on the question how to identify the alleged cluster. In the two exemplary case-studies reviewed here, the geographic and functional boundaries of a cluster have been determined by some ad-hoc manner, depending on the data sets used. The spatial scope of the cluster has been assumed not to overbound the limits of certain state counties or telephone code areas, while the samples considered have been drawn from firm lists for a set of arbitrarily determined industries.

However, we have learned from a quantitative case study of Sivitanidou (1999) that, first, primary survey data is essentially required in order to arrive at meaningful answers to our questions. Second, the relevance of the sources of agglomeration forces can be quantified with the help of indirect Likert-scale indicators.

In the light of this literature relevant to the issue of cluster identification, which is rich but diverse and not at all problem-free, we will now turn to the next section where an empirical approach is offered for the identification of a specific cluster. It attempts to find pragmatic solutions to problems related to the question how to adequately capture the geographical and the functional dimension of a specific cluster.

3. An empirical approach to the identification of a specific cluster with an application to an alleged aeronautic cluster in Northern Germany

In the preceding section we have seen that cluster identification methods focus on the identification of many clusters, rather than a specific cluster. Each of these techniques has several defects. Some are arbitrary in style such that different analysts would not develop the same results. Hence, these techniques should not be used for comparative cluster analysis. Furthermore, the methods are not complete and theoretically consistent, because they are not designed to capture all essential cluster features, such as the spatial scope of clusters as well as all types of agglomeration forces. Moreover, they are not operable. The results that these methods produce provide no starting points for public interventions, because they do not indicate market failures.

We will therefore now attempt to develop an empirical approach to the identification of a specific cluster that fulfills these needs. It is described in the following section. We have applied it to an alleged cluster of aeronautic (supplying) firms that are co-located in the Northern German region surrounding two large aeronautic firms: Airbus Deutschland GmbH and Lufthansa Technik AG. We will present our empirical findings in sections 3.1.2, 3.2 and 3.3. In the final section we provide a summary.

The development of this approach has resulted in two papers: Lublinski (2002) as well as Bönte and Lublinski (2002). They have been presented at the winter seminar of the Regional Science Association (German speaking group: Gesellschaft für Regionalforschung), Hermagor, Feb. 2002, and at the High Technology Small Firms One Day Cluster Conference, Manchester Business School, April 2002, respectively.

3.1. An empirical approach to the identification of a specific cluster

From our literature review we have learned that it is helpful to consider two cluster dimensions for an adequate identification of clusters, a geographical dimension as well as a functional dimension.

In order to capture the geographical dimension we will employ the location quotient described in section 2.2.1 among other in order to identify a cluster *search area*, of which we assume that it overbounds the 'true' boundaries of the alleged cluster to some extent. Next, we will put together a list of firms with an aeronautical affinity. Potential cluster firms are identified using a self-selection criterion. Firms that have signalled an interest in the alleged cluster by participating in the survey interviews are considered potential cluster firms. Whether or not this collection of firms constitutes in fact a cluster depends, by definition, on whether or not agglomeration advantages are being generated and exploited by these co-located firms.[54] We will hence have to analyse the functional dimension of clusters.

In section 2.4.3 we have seen that only Dumais, Ellison and Glaeser (1997) as well as Peri and Cunat (2001) have explicitly analysed the relative importance of agglomeration forces. However, these studies have been 'top-down' approaches, which have not focussed on a specific cluster. Moreover, they were confined to an analysis of only the three Marshallian forces, while Porter's effects and others have been neglected.

This empirical approach, in contrast, attempts to analyse a set of eight potential effects in a specific cluster. These advantages of being proximate have been described in section 2.1.2. We address the more comprehensive question concerning the relative impact of different agglomeration forces on firms' innovative performance. Specifically, we set out to investigate three interrelated questions both descriptively as well as econometrically:

- For what types of inter-firm linkages that may generate agglomeration advantages is proximity relevant and statistically significant?
- Which agglomeration forces in the cluster have a significant impact of firms' performance?
- Are these forces operating exclusively in clusters, while such effects are not relevant for spatially dispersed firms?

Unfortunately, the quantification of agglomeration forces is by no means an easy task. Our understanding of agglomeration forces is essentially restricted by the quality and the extent

[54] See section 3.1.1 hereafter for the cluster definition used here.

of available data. This is mainly due to the fact that official statistics can at best provoke the intangible forms of clusters to loom murkily out of the mist. We therefore believe that researchers cannot avoid to gather original firm-level data in order to get a grip of the most relevant issues in this topic. Hence, we have developed a survey to collect cluster-specific firm data (see Appendix 2).

Quite obviously, there are three main and interrelated issues of empirical measurement that have to be addressed and resolved in order to arrive at meaningful answers to our questions. First, appropriate measures need to be found for each of the various agglomeration economies. Since agglomeration forces are not directly observable, the challenge is to find indicators that adequately represent the former and that can be used to compare the extent of these forces. Moreover, indicators for firm performance are needed. Second, the geographical boundaries of clusters are not observable, either. Hence, the challenge is to develop a concept in order to appropriately determine the spatial scope of clusters. And last but not least, in order to analyze whether or not agglomerative forces are exclusively operating in clusters, or whether they are operating via different channels, one needs to refer to a control group of firms that show a considerably smaller spatial concentration. This requires both the identification of firms that in all probability are located in a geographical cluster as well as the identification of spatially dispersed firms. Moreover, firms of both groups need to be comparable with respect to key firm characteristics.

Previous research efforts that have collected cluster-specific firm-level data were descriptive case studies (Hall and Markusen (eds.), 1985; Oakey et al., 2001, Sivitanidou, 1999, see section 2.5). By contrast, we employ an econometric approach to measure which of the various types of inter-firm linkages that may, in principle, generate agglomerative advantages have in fact an impact on the innovation performance of firms. The survey used here has been designed to collect data on firms' innovation counts as well as on the perceived importance of the various types of spatially proximate inter-firm linkage flows. The basic idea underlying this concept is that it is the firms themselves that can best evaluate the relevance of such linkage flows.

Concerning the question of how to determine the geographical boundaries of clusters, previous empirical research has regarded the spatial scope of clusters as identical to the boundaries of political regions (Baptista and Swann (1996, 1999); Beaudry (2001); Beaudry and Swann (2001); Feldman and Audretsch (1999); Glaeser et al. (1992); Henderson (1994), Saxenian (1994) and Sivitanidou (1999)). Of course, the geographic scope of agglomeration advantages, which determines the geographical boundaries of a cluster,[55] does not necessarily match the spatial boundaries of political regions. However, these studies have used industry-level data, which do not allow for better solutions to the problem. By contrast, our approach defines the geographical boundaries of clusters endogenously. It is the surveyed firms themselves, that - having a maximum radius of two hours driving time in mind - systematically decide which other businesses and institutions are nearby, and thus within the potential cluster, and which ones are distant. This allows us to investigate the relevance of proximate in contrast to distant inter-firm linkages.

So far no research has directly investigated to what extent localized advantages are operating exclusively or significantly different in clusters compared to non-cluster regions. As was mentioned in section 2.4, previous measurement efforts have analyzed the impact of agglomeration effects with their research area spanning over a range of sub-national regions, without explicitly differentiating between cluster and non-cluster regions. Thus, these studies can only provide indirect answers to the question. Our approach differs from these studies, because it focuses on one specific cluster. And it makes use of a control group of spatially dispersed firms, in order to compare it with the potential cluster firms. Thus, we identify enterprises that with all probability belong to a specific cluster, as well as a group of spatially dispersed firms that are similar with respect to key firm characteristics. By doing so, we attempt to reach a quasi-experimental status, as is common in medical science.

We will now proceed to describe the approach in more detail. Specifically, we will address and resolve the following measurement issues.

- How to define a cluster?
- How to identify a (potential) cluster group as well as a control group?

[55] See Enright (1996), p. 194 (see section 2.1.1).

- How to define geographic proximity?
- How to measure agglomeration forces and firms‘ innovative performance?
- How to survey firms?
- How to analyse for which types of interfirm linkages proximity matters?
- How to analyse which agglomeration forces are operating in the alleged cluster?

The following description of the approach is organised in this same order of questions, before we turn to the empirical results in sections 3.2 and 3.3.

3.1.1. A two-dimensional cluster definition

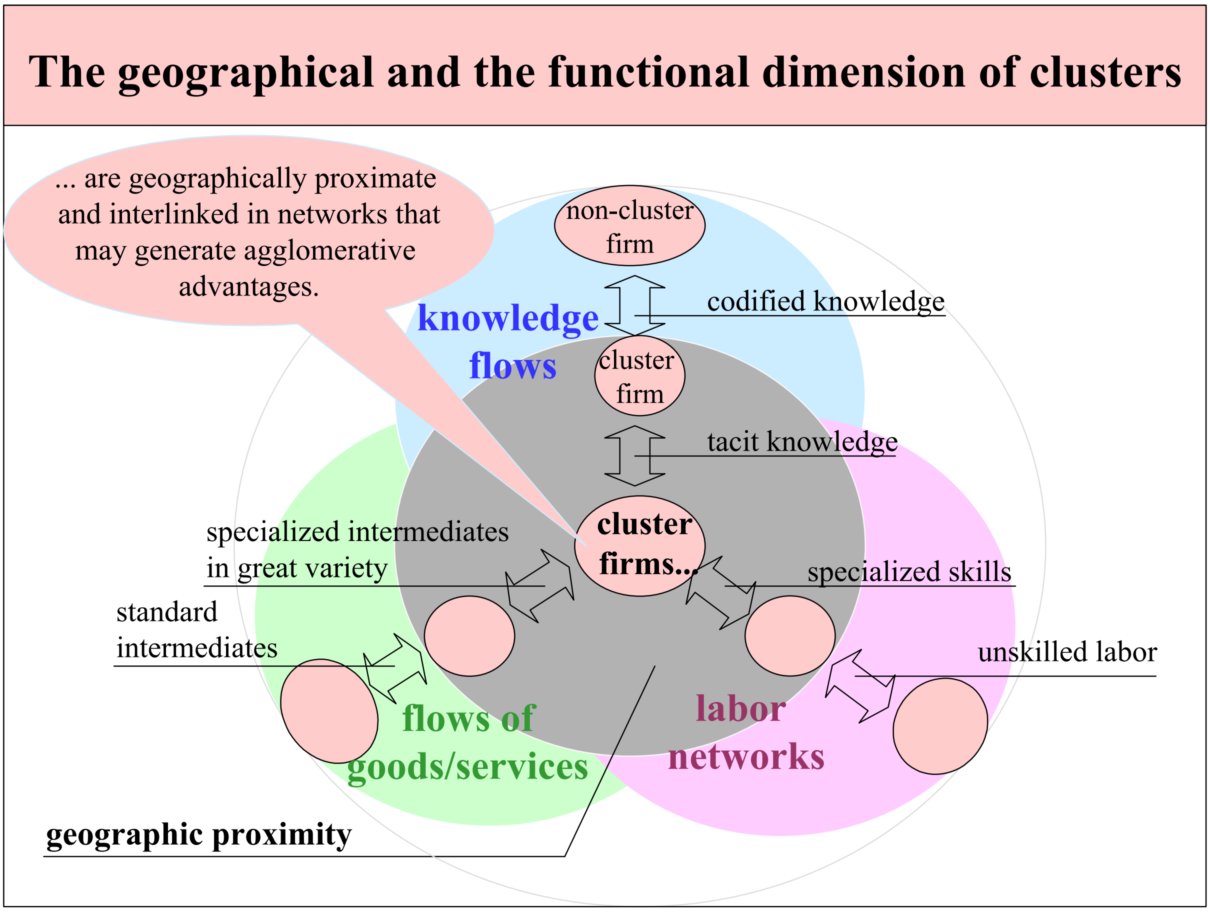
In order to integrate the constituent factors of clusters that have been mentioned in section 2.1 we suggest the following cluster definition as a starting point for our empirical analysis:

Clusters are a collection of geographically concentrated and proximate firms, organisations, institutions as well as individuals that are inter-linked by various linkage types that generate agglomeration advantages. Hence, firms in clusters have a significantly higher innovation performance, productivity and/or profitability compared with spatially dispersed firms. Its geographic scope is confined to an area that ensures an increased frequency of face-to-face contacts for a critical number of relevant persons from different firms.

Thus, clusters have two dimensions, namely a geographical as well as a functional dimension. Cluster firms are geographically concentrated and proximate (*geographical dimension*) and they are interlinked in the ways described in section 2.1.2 (*functional dimension*). In order to adequately identify clusters, it is hence reasonable to measure them along these two dimensions.

Clusters cannot be adequately identified unless both dimensions are captured. Measuring only the geographical dimension of clusters may lead to the measurement of a co-location of firms, but does not reveal to what extent nearby firms are in fact inter-linked. There may be even cases in which the co-location of firms is due to historical accident, rather than the outcome of a long-standing agglomerative process. In contrast, by measuring only the functional dimension the researcher may gain an understanding about how strongly firms in an economy are inter-linked. However, he does not know as to how spatially concentrated these economic activities are.

Figure 8: The geographical and the functional dimension of clusters



Note: In this figure only three types of inter-firm linkages are illustrated that may generate the Marshallian externalities. However, as is described in the section above this is not an exclusive list of arguments.

In this approach we will capture the geographical dimension of the alleged cluster with the help of the location quotient sketched in section 2.2.1 among other (see the following section). Thereafter we will capture the functional dimenion by, first, composing a list of potential cluster firms and, second, by analysing relevant survey data of potential cluster firms that have been identified by a self-selection criterion.

3.1.2. The concept of a cluster group and a control group

In this section we will describe how to identify not only cluster firms but also how to determine a control group of spatially dispersed firms that are similar to the cluster firms with respect to key firm characteristics. Studying only cluster firms may provide information about how effectively inter-linked these co-located firms are. However, unless these results are compared to those of a control group nothing can be said as to whether or not the effects measured are cluster-specific in the sense that they are occuring exclusively within the alleged cluster.

Therefore, we here suggest to identify cluster firms as well as control group firms. Following Kim (1995) and Hoover (1936) we propose to calculate the location quotient, which is here termed the relative concentration (RC_{Land}) of aeronautic employment (*aeroempl*) for each federal Bundesland (*Land*). Thus, we can identify *search areas* for aeronautic clusters. Additionally, we can identify regions that with all probability have no aeronautic cluster (control group):

$$\frac{aeroempl_{Land}}{empl_{Land}} \Bigg/ \frac{aeroempl_{Germany}}{empl_{Germany}} = \frac{aeroempl_{Land}}{aeroempl_{Germany}} \Bigg/ \frac{empl_{Land}}{empl_{Germany}} = RC_{Land}$$

overrepresentation if $RC_{Land} > 1$

underrepresentation if $RC_{Land} < 1$

In order to distinguish *cluster search areas* as well as non-cluster regions, we proceed as follows. Bundesländer that have an index-value of above unity are considered overrepresented concerning the region‘s aeronautic employment share in relation to the aeronautic employment share of Germany as a whole. Hence, we assume that aeronautic clusters may be found in these regions. Federal Bundesländer with an index value of below one are regarded as underrepresented. Aeronautic clusters are not believed to be found in these regions. Therefore, firms in these regions are taken as the control group.

Table 4 indicates that there is a strong collection of aeronautic activity in the city of Hamburg. As the cluster’s geographic boundaries are surely not equal to the city‘s political boundaries, we will define firms of our sample that are located in the Bundesländer surrounding Hamburg as the Northern German aeronautic cluster firms. These are firms in Hamburg, Niedersachsen, Bremen, Schleswig-Holstein and Mecklenburg-Vorpommern.[56] Firms of the following Länder are taken as the control group: Saarland, Sachsen, Berlin, Sachsen-Anhalt, Thüringen, Rheinland-Pfalz, Brandenburg and Nordrhein-Westfalen.

Table 4: Concentration of aeronautic employment in the German Länder

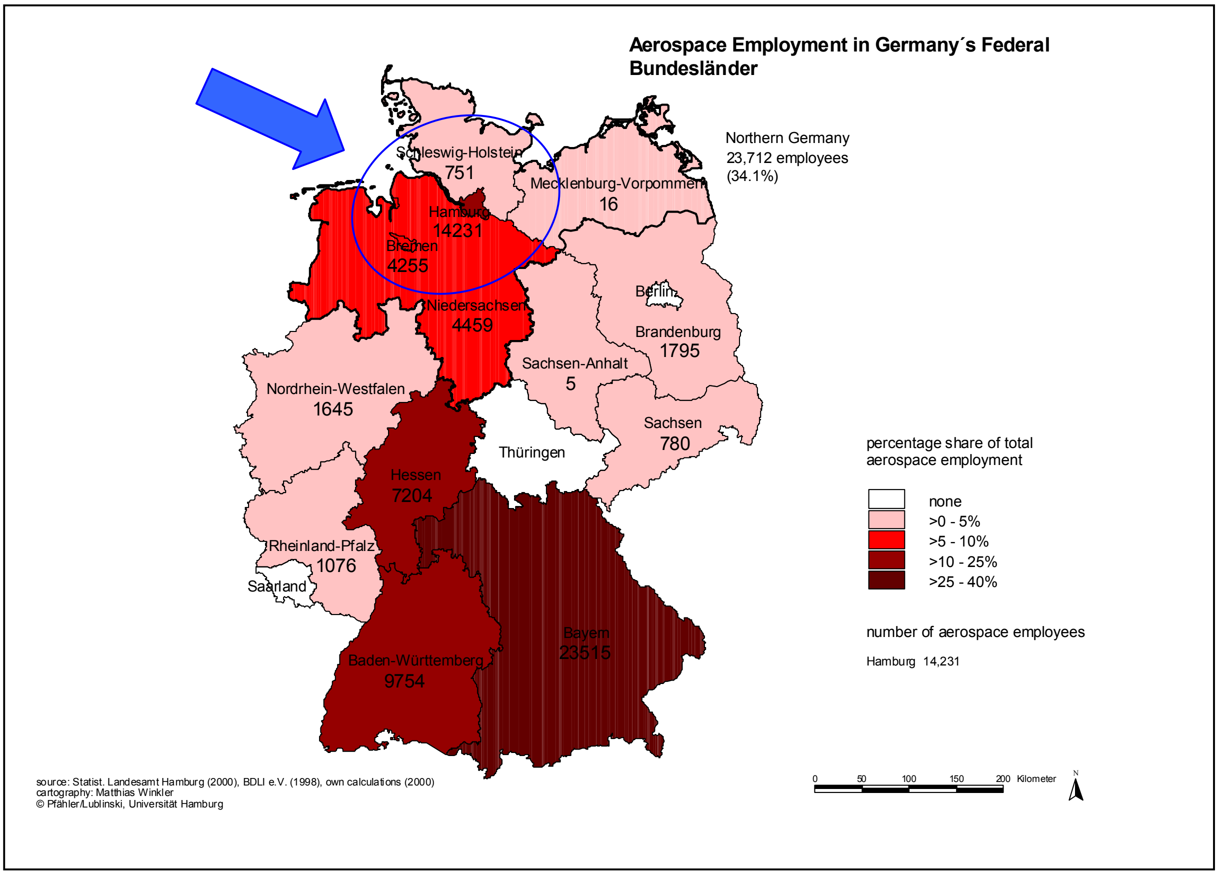
	aeronautic employment	**absolute concentration** (%-shares)	**relative concentration** >1 **over**representation <1 **under**representation	**aeronautic employment per square kilometre**
Bayern	23.515	33.8%	**2.7**	0.33
Baden-Würtemberg	9.754	14.0%	**1.4**	0.27
Hessen	7.204	10.4%	**1.8**	0.34
Nordrhein-Westfalen	1.645	2.4%	0.1	0.05
Brandenburg	1.795	2.6%	1.0	0.06
Rheinland-Pfalz	1.076	1.5%	0.4	0.05
Thüringen	-	0.0%	0.0	-
Sachsenanhalt	5	0.0%	0.0	0.00
Berlin	-	0.0%	0.0	-
Sachsen	780	1.1%	0.3	0.04
Saarland	-	0.0%	0.0	-
Northern Germany	23.712	34.1%	**2.5**	0.27
Hamburg	14.231	20.5%	**12.2**	18.85
Niedersachsen	4.459	6.4%	0.9	0.09
Bremen	4.255	6.1%	**10.4**	10.53
Schleswig-Holstein	751	1.1%	0.4	0.05
Mecklenburg-Vorpommern	16	0.0%	0.0	0.00
total employment	69.486	100%		

Note: The aeronautic employment data has been taken from the official statistics of the German Statistische Landesämter, 1999. For some Länder the aeronautic employment data could not be published due to data protection. In these cases we have alternatively used employment data of member BDLI firms, which is the German aeronautic business association.

56 Apparently, Bayern, Baden-Württemberg and Hessen have a strong agglomeration of aeronautic activities, too. However, they are excluded from this Northern German case-study.

This picture of cluster and non-cluster regions is supported, if we use different criteria, such as absolute concentration indices or a quotient of aeronautic employment and square kilometres for each Bundesland, which captures density effects as was indicated in section 2.2.2 (see Table 4). According to these official statistics the federal Bundesländer of the control group together comprise the smallest share of only 7.6% of the total German aeronautical employment and less than 0.1 aeronautic workers per square kilometre. In contrast, 20.5% and 34.1% of the industry's workforce is concentrated in the city of Hamburg and its nearby Northern German Länder respectively. And we find a remarkable number of aeronautic workers per square kilometre in Hamburg (c. 19) and Bremen (c. 11).

Figure 9:Aerospace employment in Germany's federal Bundesländer



Once we have determined a cluster search area as well as control group regions we need to identify potential cluster firms as well as control group firms. For this purpose it is reasonable to merge various lists of firms that have an aeronautic affinity. By definition, these are firms that are either officially assigned to the aeronautical sector or linked to aeronautic firms by flows that, in principle, can generate agglomeration advantages, such as input-output flows, knowlegde flows etc. (see section 2.1.2 for an overview of arguments). These potential cluster firms and control group firms have been identified by merging the following data-bases. We have chosen firm lists that have a high propensity of representing the relevant inter-firm linkages. The merged firm list has been sub-divided into the 16 federal Bundesländer of Germany:

- Airbus Deutschland GmbH, Hamburg (list of firms supplying "flying material"[57]),
- Airbus Deutschland GmbH, Hamburg (list of R&D cooperation partners)
- Hoppenstedt GmbH (list of aerospace firms)
- Regis-Online (list of aerospace firms in North-Western Germany (Weser-Ems Region))
- Hanse Aerospace e.V., Hamburg (list of the aeronautics business association members),
- Bundesverband der Deutschen Luft- und Raumfahrtindustrie e.V., Berlin (list of the aerospace business association members),
- chambers of commerce (list of aeronautical firms).

This merged file comprises 376 potential aeronautic cluster firms in Northern Germany (*cluster group*) and 138 firms of the above-mentioned Eastern and Western German Länder (*control group*) that with all probability do not operate within an aeronautic cluster. In a next step a sample of potential cluster and control group firms has to be drawn for our survey purposes that are comparable with respect to key firm characteristics, such as for example RD-personnel, sales, %-share of sales with aeronautic customers, age and the ratio of population and square kilometres of the counties (Landkreise) firms are located in.

All of the above-mentioned 376 potential cluster firms and 138 control group firms have been contacted by telephone and e-mail in order to arrange a telephone interview with each of their general managers. 111 co-located Northern German aeronautic (supplying) firms and 68 non-aeronautic cluster firms have been willing to give an interview, which corresponds to a response rate of 34.8%.

Potential cluster firms, in a more narrow sense, have thus been identified by use of a *self-selection criterion*. These 111 Northern German aeronautic (supplying) firms are considered potential cluster firms because they have signalled their interest in the cluster by participating in the survey. However, for the method to be complete, theoretically consistent and operable we need to find out, whether these firms are in fact cluster firms. This is the case if agglomeration advantages are being generated and exploited in the cluster.

3.1.3. The survey

We have interviewed general managers only, because we believe that general managers have a better overview of the various topics addressed than any other firm representative. In contrast, interviewing an R&D director, for instance, may lead to valuable data with respect to knowledge flows from and to other firms and institutions. However, he may not necessarily be competent when talking about labor market pooling effects and the firm‘s recruiting policy. Furthermore, we believe general managers were sufficiently competent for our purposes, because firms in our sample were fairly small (max. 500 employees). In case we have interiewed general managers of firms comprising multiple plants, we have focused our questions to the respective Northern German plant the manager was located at, not the total firm. This prevented the collection of irrelevant data, if for instance an interviewee represented plants in other regions, too.

Interviews were conducted in June 2001 on the basis of a detailed questionnaire[58] by a group of ten under-graduate economics students. The final questionnaire was developed following two types of pilot studies. Pre-tests were run both face-to-face as well as by telephone. Key success factors have proven to be threefold: First, the interviewers were extensively trained to actively explain the theory underlying the questionnaire as well as to effectively fix an appointment and guide through an interview. Second, substantial effort was expended in designing a sufficiently rich but short questionnaire in order to allow interviews not to exceed 15 to 20 minutes. Third, no interview was made unless interviewees had the possibility to simultaniously look at a copy of the questionnaire on a

[57] An aircraft is by definition exclusively created as a montage from so-called ”flying materials“, which includes materials, components and technical equipment/systems.
[58] The questionnaire can be found in Appendix 2.

pre-installed web-site. In some cases copies had been sent via e-mail or fax before beginning the interview.

The questionnaire is divided in four sections. The first section provides background information on the study itself and on how the data are intended to be used. The second section introduces into the topic. It contains two illustrations in order to help achieve a fast understanding of the definition of geographic proximity. Question number 1 has the mere intention to make interviewees aware of the number and various types of relevant nearby firms and institutions. The third section seeks to understand the size of the various types of inter-firm linkage flows that may generate agglomerative advantages. The fourth section looks for general information of each firm, such as innovativeness, size, age etc.

3.1.4. The concept of geographic proximity

A main problem of empirical studies on agglomeration forces is to implement the concept of geographic proximity. In many studies secondary data are used to explore the impact of agglomeration forces. Such data usually exist for certain geographic units, like states or counties. This approach is problematical, since such units are typically defined by political rather than economic borders. Unfortunately, agglomeration forces do not care about such borders.

In contrast to the previous literature, we reject to use clear-cut measures. Instead, in our study it is the firms themeselves that decide which other firms and institutions are nearby and which ones are distant. In our questionnaire we have provided the firms with different information about our concept of geographic proximity. First, as was argued in section 2.1.1 the notion of geographic proximity has been defined by a maximum radius of two hours driving time. Second, we have explained that geographic proximity allows for regular "face-to-face" contacts. Third, we have provided firms with two illustrations (see Figure 10 and Figure 11 below) in the questionnaire which gave an example of the notion.

Figure 10: Categories of spatially proximate firms and institutions

Firms have access to both spatially proximate as well as distant firms and institutions - geographic proximity (max. 2 hours driving time) may enhance regular and spontaneous face-to-face contacts

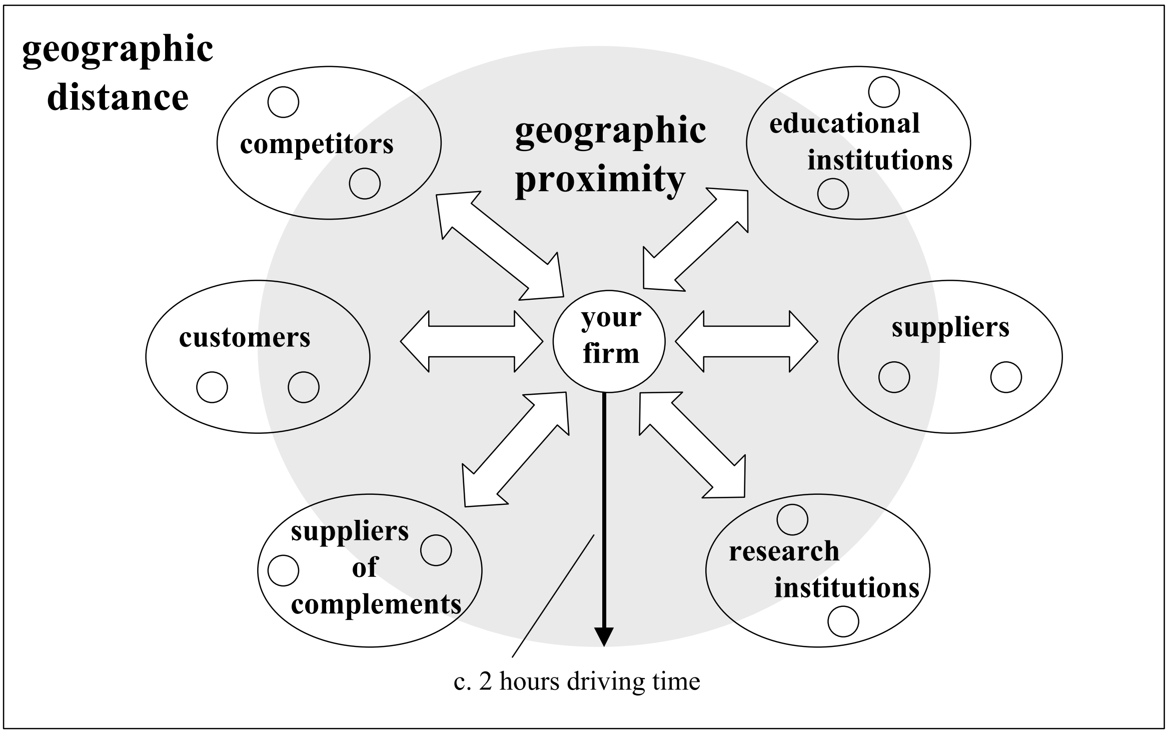
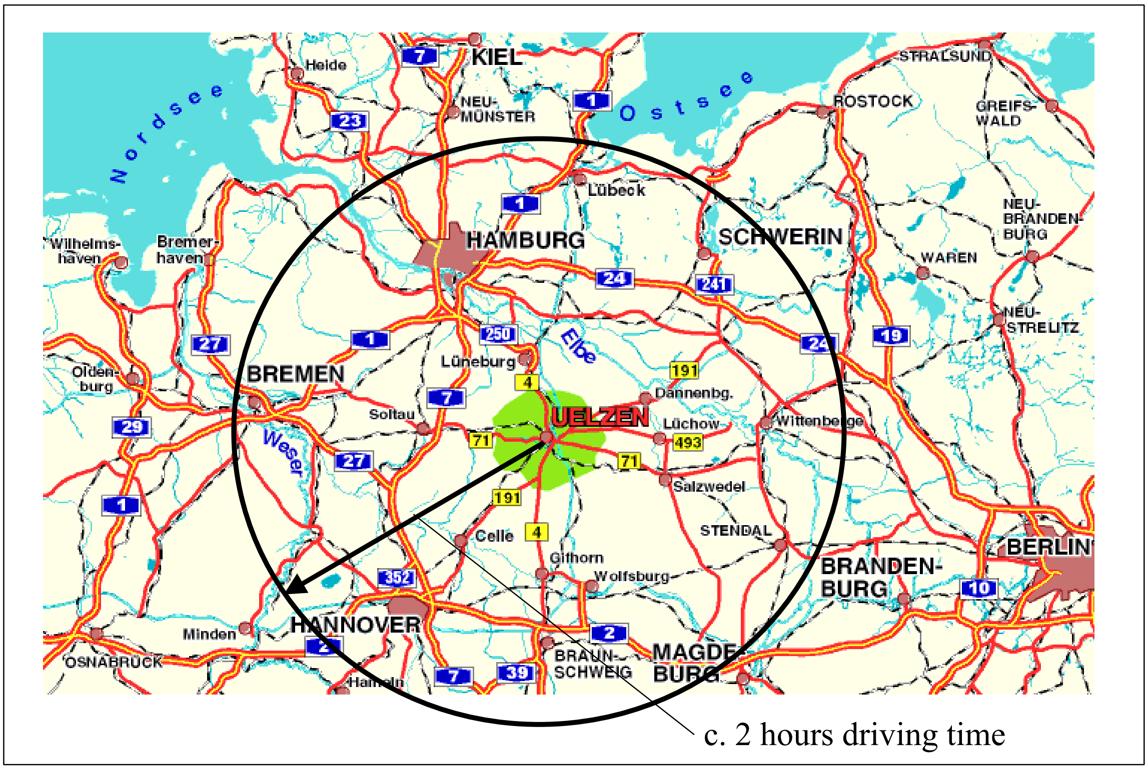


Figure 11: An example of spatial proximity for a firm in Uelzen

The concept of geographic proximity as an example for a firm in Uelzen



3.1.5. The measurement of agglomeration forces and innovation

Our attempt to analyse the relative importance of the various types of inter-firm networks poses the problem of choosing adequate indicators. For this purpose indicators need to satisfy two criteria.

First, they need to sufficiently reflect our subject of measurement. In our case this is the 'true' flow size in each inter-firm linkage type, such as the amount of knowledge spillovers or labor market pooling effects from the various sources of knowledge or labor, such as universities, customers, suppliers, competitors, etc. among others. Of course, we cannot directly measure the flow size of networks.[59]. We therefore have to find indicators that allow us to do an indirect measurement.

Second, we would like our set of indicators to allow for comparisons between the flow size of the various linkage-types, i.e. the amount of labor market pooling effects compared to the amount of knowledge spillovers etc.

Therefore, we opt for indirect or so-called latent indicators, asking for the perceived importance of inter-firm linkages. For example, we asked firms how important on a 6-point scale universities, customers, suppliers, competitors etc. are as sources of knowledge, ranging from 1 (lowest) to 6 (highest).

The strength of a set of such indicators is, that it complies with both requirements. First, these indicators give us an estimate of the flow size between firms in the various linkage types. The assumption is hence that if company representatives‘ perceived importance of, say, linkages to sources of knowledge is minimal, there are indeed only small flows of knowledge. If, however, the perceived importance is large, the respective knowledge flows are large in reality. And second, they allow to compare the importance of a given amount of the linkage flows between the various types of linkages. Hence, we will assume that the amount of knowledge spillovers occuring is less important compared to the amount of labor market pooling effects that are taking place, if the perceived importance of, for example, linkages to universities, customers etc. as sources of knowledge is smaller than the perceived importance of universities, customers, etc. as sources of labor.

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[59] We can for instance directly measure the amount of cars on a street. However, the amount of love, freedom, self-determination or, in our case, the amount of knowledge spillovers, labor market pooling or motivational effects due to rivalry etc. cannot be directly measured.

In order to differentiate between proximate and distant linkage flows, these questions are systematically asked for both inter-firm linkages in proximity (that may, in principle, generate agglomeration economies) as well as for linkages to distant firms and institutions (that, by definition, cannot generate agglomeration advantages).

However, this systematic approach applies only to those linkages for which latent indicators of the 6-point scale type (also differentiating between proximate and distant linkages) were found to be appropriate. These are linkages concerning (tacit) knowledge spillovers, labor market pooling, input output linkages, Porter-like motivational effects from local rivalry and demanding customers and trust-based linkages to business and cooperation partners. For all other linkage-types (transportation-type linkages and linkages based on complementarities) different indicators were used, that will be analysed separately. The reader is refered to the survey in the Appendix 2 for the list of indicators.

In order to measure firms' innovative performance, we employ the number of innovations as an indicator of innovative output and we distinguish between product and process innovations. In our questionnaire firms have been asked to provide the number of their innovations in the years from 1999-2001. In our survey we have provided firms with a definition of product and process innvovation that has been taken from a questionnaire of the Mannheim Innovation Panel (MIP).[60] We believe that this measure is a better indicator than the number of patents since not every innovative output is patented by firms.[61] and especially the aerospace industry seems to have an extremely low propensity to patent compared with other industries.[62]

3.1.6. Tests of hypothesis

We will test the hypothesis, that the average perceived importance of inter-firm linkages in geographic proximity is different compared to that of linkages to distant firms. The null hypothesis is that the average perceived importance of geographical proximity (Y_{prox}) is identical to that of geographic distance (Y_{dist}):

[60] Firms which reported very high numbers of innovations had been asked again to rule out misunderstandings. One cluster firm which reported unreliable numbers was excluded from the analysis.
[61] See Griliches (1990).
[62] See Verspargen and Loo (1999).

$$H_0 : Y_{prox} - Y_{dist} = 0 \quad H_1 : Y_{prox} - Y_{dist} \neq 0$$

We would assume that firms in the aeronautic cluster will regard their geographically proximate linkages as more important than linkages to distant agents. Hence, the average valuation of geographic proximity is assumed to be larger and significantly different from the valuation of geographic distance among the aeronautic cluster firms. Results will provide some evidence that agglomeration forces may be operating if the null hypothesis can be rejected and the difference between the valuation of proximity and distance is positive.

In the contrary, for the geographically dispersed firms that are not located in an aeronautic-cluster it is assumed that the average valuation of proximity is either equal or smaller compared to that of geographic distance. The null hypothesis is assumed to be not rejected in the first case, or it is rejected in the latter case.
We will therefore conduct such tests systematically for both the group of firms that have been identified as potential Northern German aeronautical cluster firms as well as for the control group of spatially dispersed firms.

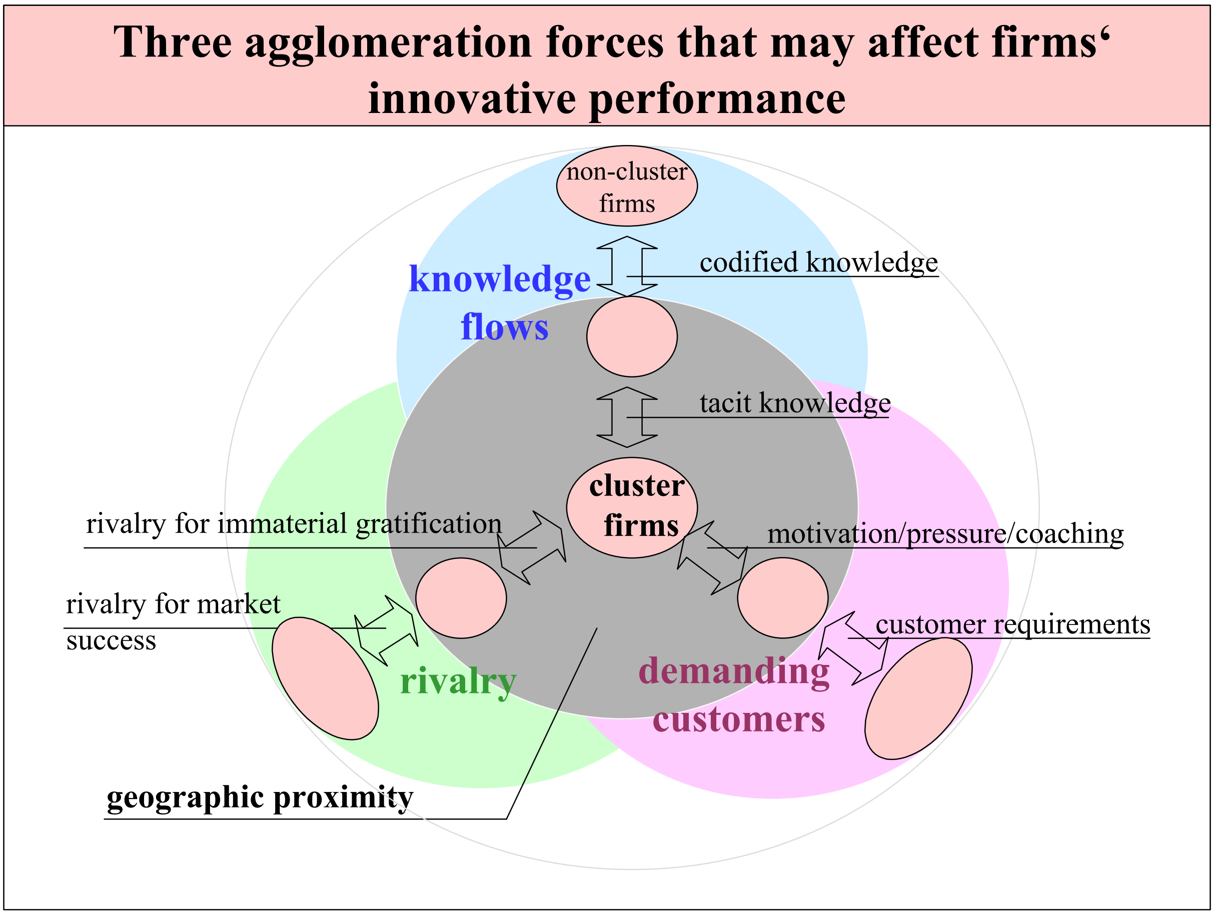
Tests are based on two dependent samples, namely the valuations of geographical proximity as well as the valuations of geographical distance. For each sample the arithmetic mean is calculated. Tests are run for the paired differences of the two arithmetic means, which are considered normally distributed.

If results suggest that proximity matters for at least some types of interfirm linkages that may generate agglomeration advantages, we will have an indication that agglomeration forces may be operating. However, these results do not indicate whether or not these firms constitute a cluster. In order to find out whether or not it is in fact a cluster we need to conduct econometric analysis to measure the impact of the various linkage flows on firms' performance.

3.1.7. Econometric specification

The dependent variable in our model is the number of innovations introduced by each firm in the period from 1999 to 2001. We assume that the number of innovations of each firm *i* is determined by potential agglomeration forces. Thereby we will focus on three of the before-mentioned eight types of agglomerative advantages, which - from a theoretical stance – may have a direct impact on firms‘ innovation performance. These are knowledge flows, rivalry as well as demanding customers.[63]

Figure 12: Knowledge flows, rivalry and demanding customers



We treat product and process innovations separately and we distinguish between the impact of firms and institutions in geographic proximity and distant firms and institutions. The following specification is used for estimation:

[63] The reader is referred to section 2.1.2 for a detailed description of these three agglomeration forces.

$$I_i^x = \mu + \mu_D D + \sum_{h=1}^{3} G_{hi}^y (\beta_h + \beta_{hD} D) + \sum_{l=1}^{5} \gamma_l FIRM_{li} + \sum_{k=1}^{N-1} \delta_k IND_k$$

x = product, process

y = proximity, distant

where the variable G represents the extent of knowledge flows (*KNOW*), rivalry (*RIVAL*) and demand pull (*DPULL*). We allow for differences between the cluster and the control group by using a dummy variable model where D is the dummy of the control group and the parameters μ_D and β_{hD} capture the differences between the cluster and the control group. If the agglomeration forces fostered innovation, we would expect to find positive and statistically significant estimates of the parameters β_h in the proximity category (y = proximity). According to our theoretical considerations the difference parameters should be negative and statistically significant in this case which would provide empirical evidence of cluster-specific effects. For the parameters of the distant category (y = distant) we do not have a priori beliefs on theoretical grounds.

To reduce the individual heterogeneity arising from non observed firm-specific characteristics we include five additional firm-specific variables (*FIRM*) into the regression. These are the logarithm of the number of R&D employes (*RD*), logarithm of the firms' sales (*SALES*), the share of aerospace products in total sales (*AEROSHARE*), the age of the firm (*AGE*) and the log of population density (*DENSITY*) of the region in which firm i is located. Industry-specific characteristics are controled for by including ten industry dummy variables (*IND*).

The number of innovations is discrete by nature and it takes a value of zero for a number of firms in our sample (see Table 24 in the appendix). Since the simple OLS estimator usually provides biased estimates for this kind of data, we have used poisson and negative binomial models which are reasonable econometric approaches for analyzing such limited dependent count variables.[64] Here, the logarithmic expected value of the number of innovations is assumed to be a linear function of the explanatory variables. However, the poisson model rests on the assumption that the mean is equal to the variance. If this

[64] See Hausman et al. (1984) and Greene (1997).

assumption is violated, poisson estimates may produce spuriously small standard errors of the estimated coefficients.[65] In the case of overdispersion the negative binomial model can be used since it allows for differences between the variance and the mean. Cameron and Trivedi (1990) have proposed regression based tests for overdispersion in the poisson model. Though not reported here, the results of their $T_{opt} - test$ provide evidence of overdispersion in our data. Therefore, only the estimation results based on the negative binomial model are reported in the following.[66] In the tables containing our estimation results, we report on the estimates of the overdispersion parameter which are statistically significant in all regressions.[67]

3.2. Descriptive results

We now present our empirical results. In this section results of our descriptive analysis are documented, while in section 3.3 we show results of our econometric analysis. Both analysis compare results for the cluster group firms and the control group firms. Comparing the cluster-group and the control group requires sufficiently homogeneous groups. Unless key firm characteristics are sufficiently similar, no results can be considered valid.

Table 5: Firm characteristics

	aeronautic cluster group	**control group**
	mean (std)	mean (std)
RD	7.79 (19.46)	11.89 (43.117)
SALES	46.86 (132.2)	46.65 (99.437)
AEROSHARE	40.21 (40.71)	35.23 (37.26)
AGE	34.54 (40.87)	32.57 (42.6)
DENSITY	1175 (960.4)	1027 (871.9)

[65] See Cameron and Trivedi (1986), p. 31.
[66] The coefficient estimates of the poisson and negative binomial model are similar but the estimated standard errors under the poisson assumption are much lower.
[67] A value of zero would suggest that the negative binomial model is inappropriate for the data. We use the NEGBIN II model which is based on the assumption that the variance-mean ratio is linear in the mean. See Cameron and Trivedi (1986, 1990).

Table 5 shows that firms in our sample are indeed similar as to the following average values of firm characteristics: %-share of RD-personnel (RD), sales in Mio. DM (SALES), %-share of sales with aeronautic customers (AEROSHARE), age (AGE) and the ratio of population and sqare kilometres of the regions (Kreise) firms are located in (DENSITY).

We now proceed by presenting our descriptive results, which focus on the question, for which types of inter-firm linkages proximity matters. We will begin with linkages that may lead to the three Marshallian forces. Next, we show our results with respect to linkages that may lead to Porter-like effects followed by transportation and transaction type linkages.

3.2.1. Marshallian externalities

3.2.1.1. Labor market pooling

Firms need qualified and specialized workers, which can be recruited from technical colleges and universities as well as from other firms. Firms in our samples have been asked to evaluate the degree of importance of different types of firms and institutions for their human resources management in the time from 1997 to 2000 on a six-point scale (1 = completely unimportant / irrelevant; 6 = very important; 0 = not existent).

In the first column in Table 6 the various types of firms and institutions are listed that may be sources of labor market pooling effects. In the second and third column average valuations are reported in the proximity and in the distance category, respectively. Figures in column four have been calculated by subtracting average values of the proximity category from values of the distance category. The two last columns show t-values and p-values respectively.

Among the cluster group none of the mentioned types of firms and institutions are considered important on average (≥3.5). Only geographically proximate technical colleges and universities of applied sciences tend to be important by a larger sub-sample of firms (>3). All other types of firms and institutions have received average values of below three.

However, for all types of educational institutions and firms proximity seems to matter, because all of them receive higher values in the proximity category compared to the distance category. The null hypothesis can be rejected in all cases at the one-percent level. This evidence does support the hypothesis that proximity matters in the case of labor market pooling effects.

Table 6: Perceived importance of proximate / distant firms and institutions as suppliers of specialised labor.

aeronautic cluster group	**proximity**	**distance**	**difference**	**t-value**	**p-value**
1 technical colleges	3.18	1.62	1.56	8.25	0.000*
2 universities of applied sciences	3.18	2.36	0.82	5.47	0.000*
3 competitors	2.64	1.95	0.69	4.67	0.000*
4 (technical) universities	2.63	2.15	0.48	4.74	0.000*
5 other firms	2.56	1.74	0.82	5.79	0.000*
6 suppliers	1.97	1.52	0.45	3.80	0.000*
7 customers	1.89	1.44	0.45	4.10	0.000*
danger of "head hunting"	3.61	2.19	1.42	8.01	0.000*
control group	**proximity**	**distance**	**difference**	**t-value**	**p-value**
1 technical colleges	3.43	1.50	1.93	7.85	0.000*
2 universities of applied sciences	3.16	1.71	1.46	7.11	0.000*
3 competitors	3.00	2.29	0.71	4.76	0.000*
4 (technical) universities	2.87	2.32	0.54	3.43	0.001*
5 other firms	1.82	1.88	-0.06	-0.35	0.727
6 suppliers	1.78	1.53	0.25	2.04	0.045*
7 customers	1.63	1.51	0.12	0.94	0.351
danger of "head hunting"	2.91	2.29	0.62	3.45	0.001*

Note: Northern german aeronautic cluster, 111 firms; control group, 68 firms. t-tests on the paired differences of mean values of two dependend samples. The null hypothesis is that differences are equal to zero. The p-value describes the exact level of significance (* statistically significant at least at the 5%-level).

These results seem to be generic, however, not cluster-typical, because similar results are found for the control group. There, all types of firms and institutions are regarded as more important on average if located nearby. In all but two categories the null hypothesis is rejected at the five-percent level.

Given the definition of labor pooling, a natural question is whether firms had the opportunity in the time between 1997 and 2000 to recruit workers that previously had been dismissed by other firms because of market shocks (risk pooling) (see Table 7). 52 cluster firms (46.8%) claimed to have benefited from risk-pooling in proximity, whereas only 16 cluster firms (14.4%) said that risk pooling was relevant in distant labor marktes, too. At first sight results do not suggest that risk pooling is cluster-specific, because relatively more non-cluster firms of the control group claim to have benefitted from nearby risk-pooling effects (50.0%). However, the average number of workers recruited by proximate firms shortly after dismissal is almost twice as large within the cluster-sample.

Table 7: Risk pooling

	risk pooling in proximity		**risk pooling in distance**	
aeronautic cluster group	**“yes“**	**“no“**	**“yes“**	**“no“**
number of firms	52	59	16	95
%-share of sample	46.8%	53.2%	14.4%	85.6%
average number of employees recruited	13.5		5.2	
control group				
number of firms	34	34	11	57
%-share of sample	50.0%	50.0%	16.2%	83.8%
average number of employees recruited	7.0		0.4	

However, besides positive effects, there may also be negative externalities due to congestion and competition. We have asked firms, how important they consider the danger of loosing workers because of head-hunting (see Table 6). In absolute terms the danger of head-hunting is regarded as important on average in proximity (3.61), not so in distance (2.19). The null hypothesis is rejected at the one percent level. Thus, the data hint at the existence of such diseconomies, for which proximity seems to matter. Diseconomies of such kind seem to be again not cluster-specific. However, they currently seem to play a much larger role on average for the Northern German cluster firms (3.61) compared to non-cluster aeronautical firms (2.91).

3.2.1.2. Access to intermediates

Firms in clusters may also benefit from a greater degree of specialisation and variety of the local supplier base. In order to evaluate the degree of specialisation of the local supplier base we compare the firms‘ perceived degree of specialisation of both proximate and distant suppliers on a six-point scale (1 = wide product spectrum; 6 = very specialised; 0 = not existent) (see Table 8). We evaluate the degree of variety of local inputs by asking firms to estimate the percentage share of inputs, purchased from geographically proximate suppliers (see Table 9).

Table 8: Perceived degree of specialisation of the proximate / distant supplier base

aeronautic cluster group	**proximity**	**distance**	**difference**	**t-value**	**p-value**
degree of suppliers‘ specialisation	2.84	4.03	-1.19	-5.55	0.000*
control group	**proximity**	**distance**	**difference**	**t-value**	**p-value**
degree of suppliers‘ specialisation	3.46	4.85	-1.40	-4.81	0.000*

Note: Northern german aeronautic cluster, 111 firms; control group, 68 firms. t-tests on the paired differences of mean values of two dependend samples. The null hypothesis is that differences are equal to zero. The p-value describes the exact level of significance (* statistically significant at least at the 5%-level).

Clearly, local suppliers in the cluster are judged hardly specialised (<3.5), whereas distant suppliers are on average relatively specialised (≥3.5). Interestingly, a large sub-sample of non-cluster firms in the control group believe that their local suppliers are on average relatively specialised (3.46).

Table 9: %-share of inputs to production purchased from suppliers in geographic proximity

%-share of inputs in proximity	0	≤10	≤20	≤30	≤40	≤50	≤60	≤70	≤80	≤90	≤100	average
aeronautic cluster group (n=111)												
number of firms	28	59	69	78	82	87	89	94	100	105	111	
%-share (n=111)	25%	53%	62%	70%	74%	78%	80%	85%	90%	95%	100%	27.6%
control group (n=68)												
number of firms	13	37	43	49	53	57	61	62	65	66	68	
%-share	19%	54%	63%	72%	78%	84%	90%	91%	96%	97%	100%	24.3%

Table 9 shows that 25% of the cluster-firms and only 19% of non-cluster firms purchase no inputs from local suppliers. And 78% of the cluster-firms and 84% of the non-aeronautical cluster firms buy less than half of their inputs in proximity. On average the %-share of inputs from proximate suppliers is very low both in the cluster-group (27.6%) as well as in the control group (24.3%).

3.2.1.3. Knowledge spillovers

Firms in clusters may also have a privileged access to specialised and tacit knowledge in geographic proximity. In order to assess how relevant proximity is to the transmission of knowledge and knowledge spillovers we analyse the perceived degree of importance of different types of firms and institutions as sources of knowledge for firms‘ innovative activities on a six-point scale (1 = completely unimportant; 6 = very important; 0 = no knowledge transfer / not existent). We have also asked firms to evaluate the danger of leaking knowledge on a six-point scale (see Table 10).

Cluster firms believe that only proximate customers are on average important (= 3.45) and they are regarded as more important than distant customers. The results of the control group are vice versa. There distant customers are considered important on average whereas proximate customers are not.

Many cluster firms fear the danger of leaking knowledge in proximity (3.02). The danger in distance is considered less relevant on average (2.37). The null hypothesis is rejected on the one percent level. This negative effect of proximity may be cluster specific, because results are vice versa in the control group. The danger is regarded as less relevant on average, but more relevant in distance than in proximity.

In the cluster group most types of firms and institutions are believed to be more important in proximity than in distance. Exceptions are fairs, suppliers and competitors. The null hypothesis is rejected on the five-percent level in the case of customers, other firms, universities, chambers of commerce, universities of applied sciences and non-university research institutions.

Table 10: Perceived importance of proximate / distant firms and institutions as sources of knowledge for innovative activities

aeronautic cluster group	**proximity**	**distance**	**difference**	**t-value**	**p-value**
1 customers	3.45	2.79	0.66	4.08	0.000*
2 suppliers	2.05	2.32	-0.26	-1.64	0.104
3 fairs and congresses	1.99	2.13	-0.14	-0.74	0.460
4 other firms	1.78	1.54	0.25	1.93	0.056
5 universities	1.72	1.00	0.72	4.97	0.000*
6 chambers of commerce	1.69	0.89	0.80	4.89	0.000*
7 universities of applied sciences	1.62	0.83	0.79	5.63	0.000*
8 non-university research institutions	1.43	1.08	0.35	2.48	0.015*
9 competitors	1.29	1.44	-0.15	1,57	0.119
danger of leaking knowledge	3.02	2.37	0.65	5.27	0.000*
control group	**proximity**	**distance**	**difference**	**t-value**	**p-value**
1 customers	2.91	3.85	-0.94	-3.52	0.001*
2 suppliers	2.12	1.63	0.49	2.26	0.027*
3 fairs and congresses	2.09	2.76	-0.67	-3.14	0.002*
4 other firms	1.88	3.78	-1.90	-6.52	0.000*
5 universities	1.87	1.38	0.49	2.32	0.023*
6 chambers of commerce	1.78	1.15	0.63	3.90	0.000*
7 universities of applied sciences	1.74	1.55	0.21	1.06	0.293
8 non-university research institutions	1.72	2.01	-0.29	-1.64	0.106
9 competitors	1.03	1.79	-0.76	-3.96	0.000*
danger of leaking knowledge	2.44	2.82	-0.38	-2.32	0.023*

Note: Northern german aeronautic cluster, 111 firms; control group, 68 firms. t-tests on the paired differences of mean values of two dependend samples. The null hypothesis is that differences are equal to zero. The p-value describes the exact level of significance (* statistically significant at least at the 5%-level).

3.2.2. Porter's market conditions

3.2.2.1. Demanding customers

Demanding customers may be of advantage to cluster-firms. In order to assess whether or not proximity helps to drive firms to a higher innovative performance we analyse, firstly, the perceived degree of pressure exerted by demanding customers on a six-point scale (1 = not true; 6 = completely true; 0 = not existent) and, secondly, the perceived extent of success with new customers due to the old customers‘ pressure (see Table 11).

Results suggest that firms of both the cluster group and control group are exposed to strong pressures exerted by local as well by distant customers (>3.5). However, the average degree of nearby customers‘ pressures is larger than that of distant customers for the cluster group and vice versa for the control group. The null hypothesis is rejected at the five- and one-percent level, respectively.

Table 11: Perceived importance of demanding customers

aeronautic cluster group	**proximity**	**distance**	**difference**	**t-value**	**p-value**
perceived degree of customers‘ pressure	4.33	3.87	0.46	2.90	0.004*
new customers due to old customers‘ pressure	3.78	3.45	0.33	2.55	0.012*
control group	**proximity**	**distance**	**difference**	**t-value**	**p-value**
perceived degree of customers‘ pressure	3.65	4.66	-1.01	-3.96	0.000*
new customers due to old customers‘ pressure	3.13	4.13	-1.00	-3.96	0.000*

Note: Northern german aeronautic cluster, 111 firms; control group, 68 firms. t-tests on the paired differences of mean values of two dependend samples. The null hypothesis is that differences are equal to zero. The p-value describes the exact level of significance (* statistically significant at least at the 5%-level).

These pressures have, on average, helped cluster firms to find new customers (>3.5) in proximity and - for a large sub-sample of cluster-firms – also in distance (3.45). It has helped non-aeronautical cluster firms, on average, to find new customers only in distance.

3.2.2.2. Rivalry

Firms in clusters may profit from motivational effects due to a more intense rivalry between proximate firms and persons. In order to assess the degree of these effects we analyse the perceived importance of rivalry on a six-point scale (1 = completely irrelevant; 6 = very important; 0 = not existent).

Table 12: Perceived importance of rivalry

aeronautic cluster group	**proximity**	**distance**	**difference**	**t-value**	**p-value**
rivalry	2.75	2.08	0.67	3.14	0.002*
control group	**proximity**	**distance**	**difference**	**t-value**	**p-value**
rivalry	1.72	1.91	-0.19	-0.67	0.505

Note: Northern german aeronautic cluster, 111 firms; control group, 68 firms. t-tests on the paired differences of mean values of two dependend samples. The null hypothesis is that differences are equal to zero. The p-value describes the exact level of significance (* statistically significant at least at the 5%-level).

Cluster firms consider rivalry and its potential motivational effects less important on average (<3.5), both in proximity and in distance. However, rivalry is regarded as more important between local agents. The null hypothesis is rejected at the one-percent level. In contrast, non-cluster firms consider competition with distant firms more important on average.

3.2.2.3. Complementarities

Furthermore, we have asked firms whether or not they knew of nearby firms that offered complements in respect to their own products. If yes, we continued to ask whether or not they were cooperating with these firms.

Table 13 shows that cluster firms have more relevant suppliers in their neighborhood than in geographic distance, while results are vice versa for the control group. Two thirds of the aeronautic cluster firms believe to have suppliers of complements in proximity, while only 59% of them know of relevant suppliers of complements in geographic distance. In contrast, the non-aeronautic cluster firms know of more distant suppliers of relevant complements (49% of firms) than of suppliers in proximity (74% of firms).

Table 14 tells us that cluster firms are more prone to cooperate in proximity, while non-aeronautic cluster firms tend to cooperate more with distant suppliers of complements. 65% (or 48 firms) of the 74 cluster firms, that claim to have relevant local suppliers of complements, are cooperating with these complementary suppliers, and 68% of the 66 firms, that claim to have relevant distant suppliers of complements, are cooperating with these firms.

Among the firms of the control group only 58% are cooperating with local complementary firms, but 64% are cooperating with distant suppliers of complements.

Table 13: Proximate and distant suppliers of complements

	proximate complements		**distant complements**	
aeronautic cluster group (n=111)	**"yes"**	**"no"**	**"yes"**	**"no"**
number of firms	74	37	66	45
%-share of sample	67%	33%	59%	41%
average number of complements				
control group (n=68)				
number of firms	33	35	50	18
%-share of sample	49%	51%	74%	26%
average number of complements				

Table 14: Cooperations with proximate and distant suppliers of complements

	proximate cooperations (n=74)		**distant cooperations** (n=66)	
aeronautic cluster group	**"yes"**	**"no"**	**"yes"**	**"no"**
number of firms	48	26	45	21
%-share of firms with complements	65%	35%	68%	32%
control group	**proximate cooperations** (n=33)		**distant cooperations** (n=50)	
number of firms	19	14	32	18
%-share of firms with complements	58%	42%	64%	36%

Note: The %-share values refer to the sample of only firms that claim to have suppliers of complements. Firms that believe there are no relevant suppliers of complements are not included in the sample. The sample size for the cluster group is n=74 (=100%) and n=66 (=100%) in the proximity and distance category respectively. The sample size for the control group is n=33 (=100%) and n=50 (=100%) in the proximity and distance category respectively (see Table 13).

3.2.3. Transportation and transaction cost advantages

3.2.3.1. Transportation cost advantages

Firms may benefit from lower transportation costs if customers and/or suppliers are nearby. Therefore, firms have been asked to what extent geographical proximity to their customers and suppliers is important on a six-point scale (1 = completely unimportant; 6 = very important; 0 = not existent) under transportation cost considerations.

Table 15 shows that the majority of firms think that the distance of deliveries is of no importance, while roughly a third of all cluster-firms consider geographical proximity to customers and suppliers important under transportation cost considerations. Only 16% and 22% of the non-aeronautical cluster firms regard proximity in this respect as important.

Table 15: Perceived importance of geographical proximity to customers / suppliers under transportation cost considerations (6-point scale)

	proximate customers		**proximate suppliers**	
aeronautic cluster group	**important (4-6)**	**unimportant (1-3)**	**important (4-6)**	**unimportant (1-3)**
number of cluster firms	42	69	38	73
%-share of cluster-firms	38%	62%	34%	66%
control group				
number of firms	11	57	15	53
%-share of firms	16%	84%	22%	78%

3.2.3.2. Trust

Lastly, we have asked firms to what degree they trust their most important business and cooperation partners on a six point scale (1 = extremly low degree of trust; 6 = very high degree of trust; 0 = not existent).

Results indicate that all firms have a high degree of trust in their business and cooperation partners (≥3.5), irrespective of geography (see Table 16). The cluster-group place on average a higher degree of trust in nearby firms. The null hypothesis is rejected in all but two categories on the five percent level, while it cannot be rejected for any category in the control group.

Table 16: Perceived degree of trust in proximate / distant business and cooperation partners

aeronautic cluster group	proximity	distance	difference	t-value	p-value
customers (98 firms)	4.59	4.32	0,27	2.62	0.010*
suppliers (86 firms)	4.22	3.99	0.23	1.76	0.081
R&D client (48 firms)	3.98	3.65	0.33	2.07	0.044*
Other cooperation partners (62 firms)	3.98	3.56	0.42	2.73	0.008*
R&D contractors (37 firms)	3.89	3.73	0.16	1.97	0.056
R&D cooperation partners (39 firms)	3.87	3.64	0.23	1.65	0.107
control group	**proximity**	**distance**	**difference**	**t-value**	**p-value**
Customers (60 firms)	4.53	4.50	0.03	0.30	0.770
R&D clients (26 firms)	4.42	4.19	0.23	1.44	0.161
R&D cooperation partners (firms)	4.30	4.26	0.04	0.33	0.774
Supplier (59 firms)	3.98	3.81	0.17	1.32	0.191
R&D contractor (22 firms)	3.95	3.95	0.00	0.00	1.000
Other cooperation partners (firms)	3.73	3.78	-0.05	0.57	0.570

Note: Northern german aeronautic cluster, 111 firms; control group, 68 firms. t-tests on the paired differences of mean values of two dependend samples. The null hypothesis is that differences are equal to zero. The p-value describes the exact level of significance (* statistically significant at least at the 5%-level)

3.3. Econometric results

In the preceding section we have analysed for which types of inter-firm linkages spatial proximity matters. However, so far we have gained no knowledge as to which agglomeration forces are indeed operating within the cluster. Hence, we will now present results of an econometric analysis that has tested which of three specific agglomeration forces are at work as measured by a significant impact on the number of firms‘ product and process innovations.

3.3.1. Product innovations

First, we present the results for product innovation estimations. We discuss the impact of firms and institutions in proximity (intraregional) as well as the impact of distant firms and institutions (interregional). We have decided to investigate the impact of intra- and interregional effects separately.[68]

Table 17: Product innovation estimation results: The effects of intra-regional knowledge flows, rivalry and demand pull (negative binomial model)

PROXIMITY	(1)	(2)	(3)
Constant	0.6452 (0.45582)	1.3350 (0.92149)	-0.66982 (1.0714)
KNOW	0.27608 (0.17905)	0.18091 (0.14278)	0.21477 (0.15062)
RIVAL	0.26298 (0.057555)***	0.15747 (0.07938)**	0.11265 (0.0821)
DPULL	-0.001627 (0.10036)	-0.0233 (0.08772)	-0.0172 (0.09857)
Constant *D*	-0.19806 (0.80941)	-0.19806 (0.80941)	-0.0663 (0.77448)
KNOW · *D*	0.49214 (0.31864)	0.58883 (0.29378)**	0.64929 (0.27646)**
RIVAL · *D*	-0.53080 (0.14026)***	-0.34664 (0.14765)**	-0.34579 (0.13898)**
DPULL · *D*	-0.23253 (0.14250)	-0.20034 (0.15244)	-0.24373 (0.15029)
ln(RD)		0.10006 (0.02100)***	0.0868 (0.02052)***
ln(SALES)		-0.03762 (0.09644)	0.0586 (0.10010)
AEROSHARE		-0.0072 (0.00419)*	-0.0005 (0.00469)
AGE		-0.0006 (0.00322)	0.0009 (0.00299)
ln(DENSITY)		0.0803 (0.12432)	0.13555 (0.12285)
α	2.1246 (0.27886)	1.7514 (0.26599)	1.4179 (0.23120)
Log-Likelihood	-489.476	-475.624	-460.366
LR-tests:			
Cluster-effects	21.4***	16.65***	19.21***
Industry-effects	-	-	30.51***

Notes: The standard errors are reported in parantheses. The column (3) includes unreported industry-specific dummies. D is the dummy variable of the control group. The parameter α is the overdispersion parameter.*denotes significant at the 10 % level;** denotes significant at the 5 % level;***denotes significant at the 1 % level. Number of observations: 178.

The results for the intra-regional impact of rivalry, knowledge flows and demand pull are reported in Table 17. Column (1) contains results of a regression where only potential agglomeration forces are included, column (2) controls for firm characteristics and column (3) includes industry-specific effects. A likelihood ratio (LR-) test shows that the industry-specific effects are statistically significant. Results suggest that local external knowledge sources, rivalry as well as demanding customers do not have any impact on the number of product innovations of cluster firms. Although columns (1) and (2) report a statistically significant coefficient of the variable RIVAL which would confirm the Porter (1990) hypothesis, this coefficient becomes statistically insignificant when we control for industry-specific effects. This may reflect the fact that the degree of rivalry is industry-specific. The results of a LR-test indicate that the control group differs significantly from the cluster group with resepect to the impact of agglomeration forces. As theoretical considerations suggest, the estimate of the difference parameter of the variable RIVAL is negative for the control group. The estimated coefficient of the variable KNOW, however, is higher for the control group which does not correspond to the theoretical considerations. This result is rather robust and does not change when firm and industry-specific controls are included. The only firm specific variable which is statistically significant is the number of R&D employees.[69]

The results are somewhat different for the {inter}-regional impact of knowledge flows, rivalry and demand pull (see Table 18). The estimated coefficient of the variable KNOW is positive and statistically significant for the cluster firms. This result is rather robust to the inclusion of different controls. The coefficient of the variable RIVAL is negative but this effect becomes statistically insignificant when industry dummies are included. Now, not only the estimated coefficient of the R&D variable is statistically significant but also the coefficient of the variable DENSITY. This result can be interpreted in the way that this variable may control for linkages in proximity which are not included in this regression.

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[68] There is some correlation between the two measures for each of the variables. This may increase the standard errors of the estimated coefficients in regressions where both measures are included.
[69] Do bear in mind that the estimated coefficient cannot be interpreted as marginal effects because the estimation technique is not OLS.

Table 18: Product innovation estimation results: The effects of inter-regional knowledge flows, rivalry and demand pull (negative binomial model)

DISTANCE	(1)	(2)	(3)
Constant	1.9222 (0.28906)***	1.0168 (0.92484)	0.6188 (1.5166)
KNOW	0.3510 (0.16378)**	0.31795 (0.12389)**	0.3287 (0.13875)**
RIVAL	-0.1639 (0.06924)**	-0.15799 (0.07368)**	-0.0554 (0.08529)
DPULL	-0.0236 (0.07512)	-0.0278 (0.07408)	-0.0308 (0.09249)
Constant *D*	- 0.1484 (0.86127)	-0.0519 (0.86767)	-0.3526 (0.89888)
KNOW · *D*	0.4644 (0.38697)	0.5119 (0.27840)*	0.5852 (0.27835)*
RIVAL · *D*	0.1791 (0.14153)	0.1058 (0.12723)	0.0576 (0.11738)
DPULL · *D*	-0.42608 (0.17061)**	-0.4437 (0.16080)***	-0.3640 (0.15776)**
ln(RD)		0.1111 (0.01682)***	0.0964 (0.02040)***
ln(SALES)		0.0052 (0.08988)	0.0615 (0.08635)
AEROSHARE		-0.0022 (0.00373)	-0.0004 (0.00503)
AGE		-0.0026 (0.00456)	-0.0022 (0.0041)
ln(DENSITY)		0.19493 (0.10964)*	0.24428 (0.11462)**
α	2.3031 (0.27731)	1.7145 (0.26548)	1.4032 (0.22970)
Log-Likelihood	-494.9723	-473.8193	-460.0516
LR-tests:			
Cluster-effects	16.57***	20.77***	17.74***
Industry-effects	-	-	27.53***

Notes: The standard errors are reported in parantheses. The column (3) includes unreported industry-specific dummies. D is the dummy variable of the control group. The parameter α is the overdispersion parameter.*denotes significant at the 10 % level;** denotes significant at the 5 % level;***denotes significant at the 1 % level. Number of observations: 178.

Again, LR-tests suggest that differences between the cluster firms and the control group exist. Demanding customers located in distance seem to have a negative impact on the number of product innovations in the control group since the estimated coeffecient of the variable DPULL is negative and statistically significant. Moreover, the estimated coefficient of the variable KNOW is higher for the control group firms. However, this difference is merely significant at the 10% level.

3.3.2. Process innovations

We start with the discussion of the impact of firms and institutions in proximity (intra-regional) on process innovations. The results are reported in Table 19. They suggest that knowledge flows, rivalry and demand pull do not have any impact on the number of process innovations of the cluster firms when one controls for firm-characteristics and industry-specific effects.

Table 19: Process innovation estimation results: The effects of inter-regional knowledge flows, rivalry and demand pull (negative binomial model)

PROXIMITY	(1)	(2)	(3)
Constant	-0.309 (0.47332)	0.28657 (0.88850)	0.52116 (1.2126)
KNOW	0.296 (0.13842)**	0.0833 (0.12795)	0.07971 (0.15333)
RIVAL	0.042 (0.06986)	0.0727 (0.08062)	0.07034 (0.09439)
DPULL	0.193 (0.08097)**	0.0813 (0.08212)	0.14832 (0.10279)
Constant D	1 .609 (0.73260)**	0.4127 (0.69001)	0.59724 (0.78801)
KNOW · D	-0.152 (0.28129)	0.08036 (0.26191)	0.1 5520 (0.27889)
RIVAL · D	-0.176 (0.14956)	-0.18897 (0.13847)	-0.22768 (0.16392)
DPULL · D	-0.126 (0.13869)	-0.00787 (0.13280)	-0.04866 (0.15947)
ln(RD)		0.0530 (0.01850)***	0.0639 (0.02204)***
ln(SALES)		0.224 (0.07577)***	0.1912 (0.08321)**
AEROSHARE		-0.00309 (0.00322)	-0.0043 1 (0.00426)
AGE		-0.00383 (0.00439)	-0.00306 (0.0046077)
ln(DENSITY)		0.02071 (0.10315)	-0.00881 (0.11384)
α	1.7671 (0.25585)	1.4595 (0.22742)	1.2919 (0.21560)
Log-Likelihood	-433.630	-421.9714	-413.7444
LR-tests:			
Cluster-effects	9.49**	2.97	4.59
Industry-effects	-	-	16.45*

Notes: The standard errors are reported in parantheses. The column (3) includes unreported industry-specific dummies. D is the dummy variable of the control group. The parameter α is the overdispersion parameter.*denotes significant at the 10 % level;** denotes significant at the 5 % level;***denotes significant at the 1 % level. Number of observations: 178.

Since LR-tests do not show statistically significant differences between the cluster and the control group, the same result holds for the control group. Besides the coefficient of the R&D variable, the coefficient of the variable SALES is now statistically significant and positive. This variable captures the effects of firm size and therefore results suggest that the number of process innovations increases with the firm size.

Table 20: Process innovation estimation results: The effects of inter-regional knowledge flows, rivalry and demand pull (negative binomial model)

DISTANCE	(1)	(2)	(3)
Constant	1.0977 (0.19651)	0.83472 (0.85756)	0.80649 (1.0415)
KNOW	0.15637 (0.15505)	0.14393 (0.13505)	0.20933 (0.17583)
RIVAL	0.0826 (0.09386)	0.08265 (0.095171)	0.06638 (0.11674)
DPULL	-0.0489 (0.09961)	-0.03714 (0.06682)	-0.00862 (0.09097)
Constant D	0.0106 (0.85033)	-0.16375 (1.0151)	0.11948 (0.93543)
KNOW · D	0.0854 (0.27263)	-0.11121 (0.24887)	-0.10875 (0.28259)
RIVAL · D	-0.1810 (0.14516)	-0.14792 (0.14685)	-0.17659 (0.16138)
DPULL · D	0.0781 (0.21806)	0.14336 (0.18802)	0.11001 (0.17600)
ln(RD)		0.0635 (0.01781)***	0.0652 (0.0234)***
ln(SALES)		0.2225 (0.07389)***	0.2071 (0.08044)**
AEROSHARE		-0.00361 (0.00323)	-0.0045 1 (0.04329)
AGE		-0.00424 (0.00488)	-0.00359 (0.00507)
ln(DENSITY)		0.03409 (0.10755)	0.02250 (0.11810)
α	1.9190 (0.25700)	1.4802 (0.23247)	1.3193 (0.21680)
Log-Likelihood	-439.1833	-422.6947	-415.2761
LR-tests:			
Cluster-effects	2.97	3.51	3.94
Industry-effects	-	-	14.83

Notes: The standard errors are reported in parantheses. The column (3) includes unreported industry-specific dummies. D is the dummy variable of the control group. The parameter α is the overdispersion parameter.*denotes significant at the 10 % level;** denotes significant at the 5 % level;***denotes significant at the 1 % level. Number of observations: 178.

The same results occur when the impact of distant firms and institutions is investigated (see Table 20). All in all, results suggest that process innovations are not influenced by knowledge flows, rivalry and demand pull. Neither are they influenced by firms and institutions in proximity nor by distant firms and institutions.

3.3.3. Product innovations and different knowledge sources

It is likely that much of the relevant information on knowledge flows gets lost due to our aggregating of all knowledge sources into one variable (KNOW). Therefore, we have constructed subaggregates which allows us to investigate the impact of different external sources of knowledge on the firms' number of innovations. These are the flows of knowledge from vertically related firms (KNOW_VER), competitors and other firms (KNOW_HOR), scientific institutions (KNOW_SCI) and other institutions, like fairs and congresses (KNOW_INS).

Table 21 contains estimation results for the impact of intra-regional effects on product innovations.[70] The estimated coefficient of the variable KNOW_HOR is statistically significant which implies that knowledge flows from local rivals and other firms have a positive impact on the number of product innovations of the cluster firms. In contrast, the estimated coefficient of the variable KNOW_VER is negative but merely weakly significant when controlled for firm-characteristics and industry-specific effects. Knowledge flows from scientific and other institutions do not seem to have any impact since the estimated coefficients of the variables KNOW_SCI and KNOW_INS are statistically insignicant. Again, LR-tests indicate that differences between the control group and cluster firms exist. In contrast to cluster firms, the estimated coefficient of the variable KNOW_HOR is significantly lower for the firms of the control group and the estimated coefficient of the variable KNOW_SCI is significantly higher. According to these results, product innovations of the control group tend to be positively affected by knowledge flows from local scientific institutions while other external knowledge sources in proximity do not have a significant impact. The estimated coefficient of the variable RIVAL is still significantly lower and negative for the firms of the control group.

[70] The variable DPULL is not included because previous estimation results suggest that it has no significant impact on the product innovations of cluster firms.

Table 21: Product innovation estimation results: The effects of intra-regional knowledge flows from different knowledge sources and rivalry (negative binomial model)

PROXIMITY	(1)	(2)	(3)
Constant	0.88159 (0.45493)	1.5384 (0.76460)**	0.05913 (0.95375)
KNOW_VER	-0.30587 (0.15499)**	-0.28248 (0.11574)**	-0.20828 (0.11304)*
KNOW_HOR	0.32806 (0.18779)*	0.39239 (0.15104)***	0.44856 (0.15804)***
KNOW_SCI	0.18560 (0.14550)	0.11131 (0.11138)	0.03226 (0.14112)
KNOW_INS	0.21001 (0.14250)	0.09321 (0.13798)	0.02680 (0.14478)
RIVAL	0.20446 (0.07286)***	0.10369 (0.08272)	0.05129 (0.08611)
Constant · *D*	0.13651 (0.72542)	-0.61655 (0.62867)	-0.57156 (0.61206)
KNOW_VER · *D*	0.27812 (0.26052)	0.36184 (0.22469)	0.24492 (0.20505)
KNOW_HOR · *D*	-0.41760 (0.28577)	-0.58642 (0.24711)**	-0.56871 (0.25564)**
KNOW_SCI · *D*	0.32334 (0.19045)*	0.37396 (0.15865)**	0.46959 (0.17817)***
KNOW_INS · *D*	-0.05299 (0.24227)	0.02492 (0.23945)	0.06989 (0.22957)
RIVAL · *D*	-0.52615 (0.15719)***	-0.37084 (0.16325)**	-0.31842 (0.15303)**
ln(RD)		0.10720 (0.02001)***	0.09912 (0.02207)***
ln(SALES)		-0.04791 (0.09124)	0.07601 (0.08749)
AEROSHARE		-0.00616 (0.00423)	-0.00174 (0.00499)
AGE		-0.001748 (0.00288)	-0.00086 (0.00288)
ln(DENSITY)		0.07298 (0.11068)	0.10508 (0.10333)
α	1.9818 (0.26823)	1.5970 (0.24571)	1.2787 (0.21332)
Log-Likelihood	-484.1902	-469.1649	-454.1324
LR-tests:			
Cluster-effects	20.79***	20.50***	22.09***
Industry-effects	-	-	30.07***

Notes: The standard errors are reported in parantheses. The column (3) includes unreported industry-specific dummies. D is the dummy variable of the control group. The parameter α is the overdispersion parameter.*denotes significant at the 10 % level;** denotes significant at the 5 % level;***denotes significant at the 1 % level. Number of observations: 178.

Similar results are obtained for the inter-regional impact of knowledge flows (see Table 22). Again, the estimated coefficient of the variable KNOW_HOR is positive and statistically significant which implies that knowledge flows from distant competitors and other firms have a positive impact on product innovations of the cluster firms.

Table 22: Product innovation estimation results: The effects of inter-regional knowledge transfer from different knowledge sources and rivalry (negative binomial model)

DISTANCE	(1)	(2)	(3)
Constant	1.6070 (0.29810)***	2.0423 (0.77942)***	0.6359 (0.97206)
KNOW_VER	-0.2825 (0.12264)**	-0.2232 (0.10189)**	-0.1882 (0.11889)
KNOW_HOR	0.4743 (0.19198)	0.4369 (0.17282)**	0.3775 (0.19220)**
KNOW_SCI	0.1199 (0.19776)	-0.1178 (0.16394)	-0.0603 (0.15701)
KNOW_INS	0.1754 (0.21669)	0.1766 (0.17360)	0.1457 (0.15462)
RIVAL	-0.0473 (0.10260)	-0.1012 (0.09793)	-0.0109 (0.11253)
Constant · *D*	-1.2391 (0.98891)	-1.8470 (0.86129)**	-1.6458 (0.80110)**
KNOW_VER · *D*	0.5540 (0.26583) **	0.5254 (0.23705)**	0.3929 (0.21394)*
KNOW_HOR · *D*	-0.6237 (0.31884)**	-0.5949 (0.24884)**	-0.4704 (0.25317)*
KNOW_SCI · *D*	0.1306 (0.28385)	0.3740 (0.20724)*	0.4211 (0.17941)**
KNOW_INS · *D*	-0.0224 (0.39957)	-0.0022 (0.30750)	0.0147 (0.26447)
RIVAL · *D*	0.0348 (0.19342)	0.0353 (0.16289)	0.0332 (0.15121)
ln(RD)		0.12249 (0.01981)***	0.104 (0.02173)***
ln(SALES)		-0.0097 (0.08928)	0.0731 (0.08078)
AEROSHARE		-0.0051 (0.00401)	-0.0043 (0.00507)
AGE		-0.0004 (0.00391)	-0.0011 (0.00380)
ln(DENSITY)		0.0518 (0.10155)	0.0099 (0.10714)
α	2.2349 (0.28359)	1.6705 (0.23875)	1.3603 (0.2213)
Log-Likelihood	-493.2630	-472.9489	-458.7779
LR-tests:			
Cluster-effects	14.68**	23.08***	20.12***
Industry-effects	-	-	28.34***

Notes: The standard errors are reported in parantheses. The column (3) includes unreported industry-specific dummies. D is the dummy variable of the control group. The parameter α is the overdispersion parameter.*denotes significant at the 10 % level;** denotes significant at the 5 % level;***denotes significant at the 1 % level. Number of observations: 178.

Thus, it seems that cluster firms benefit from knowledge flows from horizontally related firms irrespective whether these firms are located in proximity or distance. Results suggest that significant differences between the cluster and the control group exist. The estimated coefficient of the variable KNOW_HOR is significantly lower while the estimated coefficients of the variables KNOW_VER and KNOW_SCI are significantly higher. The estimated coefficient of the variable RIVAL is still negative but it is statistically insignificant now. These results suggest that the product innovations of the control group are positively affected by knowledge flows from distant scientific institutions.

However, results do not allow us to say whether these knowledge flows are due to knowledge spillovers or due to voluntary cooperations between firms. However, descriptive statistics presented in section 3.2.1. indicate that spillovers are existent. Cluster firms evaluate the danger of leakage of knowledge between geographically proximate agents on average as highly relevant.

3.4. Summary

In the above-described analysis we have conducted a descriptive as well as an econometric analysis, which we will now revisit to summarize the findings.

We have tested, for which types of inter-firm linkages, that may generate agglomerative advantages, geographic proximity matters. The analysis is focused to the case of firms with an aeronautic affinity in Germany. These are firms that belong to at least one of the following groups: firms that are being assigned to the aeronautic industry, firms that are members to an aeronautic business association, R&D co-operation partners of aeronautic firms or suppliers of technologically critical “flying material“ to aeronautic firms. More specifically a group of aeronautical cluster firms in Northern Germany is analysed together with a control group of firms in Western and Eastern German federal Bundesländer, that with all probability are not located in a comparable agglomeration of aeronautical firms. The data have been gathered by telephone interviews.

Results are here summarised using three criteria: Firstly, we will ask, for which types of networks proximity is *relevant*, in the sense that the mean values in the proximity category are larger than average (≥3.5) for at least one category of firms and institutions representing the sources of potential advantages. Secondly, it is asked for which types of networks proximity is statistically *significant.*[71] This is the case if the null hypothesis can be rejected at the five-percent level at least in one category of firms and institutions. Lastly, it is asked what types of networks are *cluster-specific* in the sense that the mean values in each proximity category are higher than in the distance category for the cluster-group *and* vice versa or equal for the control group.

Results indicate that vertical linkages to spatially proximate customers that excert pressures upon their suppliers and that function as an important source of knowledge are important in the Northern German aeronautics cluster. Only for these two effects proximate linkages are relevant, statistically significant and cluster-specific. For inter-firm networks that may generate labor market pooling effects (only head-hunting) and trust-based effects proximity is relevant and significant but not cluster-specific. Proximity seems not to be relevant on average (<3.5), though statistically significant for horizontal inter-firm linkages that may lead to motivational effects due to rivalry. Proximity seems to be neither relevant nor significant for the accessibility to intermediate goods and services.

Table 23: Relevance, significance and specificity of proximity to different types of inter-firm linkages

type of linkage/effect	**proximity relevant**	**proximity significant**	**cluster specificity**	**remark**
labor market pooling	yes	yes	no	only head-hunting relevant
access to intermediates	no	no	no	t-tests only partly available
knowledge spillovers	yes	yes	yes	only customers relevant
rivalry	no	yes	yes	
demanding customers	yes	yes	yes	
complementarities	-	-	-	no t-tests available
trust	yes	yes	no	
transportation cost advantage	-	-	-	no t-tests available

[71] As we have opted for two-tailed t-tests significant results may be found both in the case that average values in the proximity category are larger than average values in the distance category and vice versa. We would expect the group of cluster firms to have higher average proximity valuations relative to distance valuations. Hence we check whether or not this is the case, though we do not explicitly report about it.

The purely descriptive results concerning transportation networks and networks between suppliers of complementarities indicate that proximity does matter. However, for these two networks no t-tests are available. Only in the cases of spillovers, rivalry and demanding customers results tend to be cluster-specific.

The fact that proximity seems to matter at least for some types of inter-firm linkages suggests that the spatial concentration of aeronautic (supplying) firms in Northern German is a potential cluster. We now turn to the econometric results to find out if it is in fact a cluster in the sense that cluster firms are effectively interlinked such that agglomeration advantages are being generated and exploited.

In the econometric analysis we have addressed three issues. First, we have addressed the issue of what the relevant agglomerative forces are that affect firms‘ innovation performance. Our results clearly suggest that knowledge flows from nearby rivals and 'other firms' increase the expected number of product innovations of aeronautic (supplying) firms in Northern Germany. Product innovations are neither influenced by rivalry nor demanding customers, while process innovations seem not to be effected by any force.

Second, we have asked whether or not geography matters. We have expected potential cluster firms to benefit more strongly from spatially proximate knowledge flows in contrast to distant knowledge flows. However, results show that knowledge flows both intra- as well as inter-regionally. Thus, results do not provide any evidence that geography really matters. Concerning the other potential agglomerative advantages, namely rivalry and demanding customers, no statements can be made as to whether or not geography matters, because neither of these two forces has an impact on innovations of cluster firms.

Third, we have investigated whether there are statistically significant differences between the potential cluster and the control group. This question can be answered affirmatively, though contrary to our presumption, on the following grounds: Surprisingly, proximity does matter for knowledge flows in the case of firms of our control group, though not for aeronautic cluster firms (proximate flows from horizontally linked firms are the only exception). Moreover, motivational effects from proximate rivals are negatively correlated with the innovativeness of control group firms, while there is no impact in the case of cluster-firms. Specifically, firms of the control group differ from cluster firms as to the sourcing of knowledge. While control group firms benefit from knowledge flows from proximate (as well as distant) scientific institutions, cluster firms benefit from horizontally related firms.

In a nutshell, results suggest that agglomeration forces are at best operating weakly. Hardly any of the relevant linkages between nearby firms have an effect on the innovativeness of firms. Knowledge flows from proximate and horizontally linked firms are the mere exception. Unless other agglomerative advantages exist that may directly affect productivity or profitability of firms and that are not analyzed here, the aeronautic (supplying) firms in Northern Germany constitute at best a weak cluster. Rather these findings suggest that it is a strong co-location of firms with an aeronautical affinity that are, however, hardly inter-linked in an effectful manner.

4. Summary and conclusion

Economic activities are often clustered in geographic space. Groups of spatially concentrated and functionally related firms often show a remarkable performance, which is believed to stem from so-called agglomeration forces. Despite the importance of the phenomenon, the issue of how to identify a specific cluster has not yet been sufficiently resolved. We have suggested to consider two cluster dimensions that capture the various constituent factors of the phenomenon that have been mentioned in the literature. In this dissertation a cluster has been defined as a collection of geographically concentrated and proximate firms, organisations, institutions as well as individuals (*geographical dimension*) that are inter-linked by various linkage types that generate agglomeration advantages (*functional dimension*). Hence, firms in clusters have, by definition, a significantly higher innovation performance, productivity and/or profitability compared with spatially dispersed firms. Its geographic scope is confined to an area that ensures an increased frequency of face-to-face contacts for a critical number of relevant persons from different firms.

This dissertation has attempted to find out how to adequately identify a specific cluster. This issue has been framed in the form of the following two interrelated questions, which we will now revisit to discuss them in the light of our findings:

- How to detect a spatial concentration of co-located firms as well as the spatial scope of an alleged cluster (*geographical dimension*)?
- How to measure which, if any, agglomerative forces are operating in an alleged cluster (*functional dimension*)?

A review of the two main strands of the existing cluster identification literature has shown that contributions have focussed either on the first question or on the second. Only few studies have attempted to combine the techniques in order to capture both dimensions (Czamanski, 1977, Streit, 1969, Richter, 1969). The techniques that employ employment data can be used in order to find out to what extent and where firms of one sector (*spatial concentration*) or of many sectors (*spatial association*) are co-located. However, they do not reveal to what extent these firms are inter-linked. In contrast, Input Output (I/O) methods can be used to identify groups of industries that are inter-linked by relevant flows of goods and services, though they cannot indicate to what extent these industries are co-located. Moreover, I/O methods analyse one relevant linkage type. However, many more linkage types, such as knowledge flows among other, can be a source for agglomeration advantages and should thus be captured. Therefore, these techniques are neither complete nor theoretically consistent. Furthermore, these techniques are 'top-down' approaches that are used to identify many clusters. They do not provide detailed information with respect to a specific cluster.

Next, some I/O techniques use rather arbitrary cut-off schemes and, hence, cannot provide adequate results when used in comparative cluster studies (Roelandt et al., 1997, Hauknes et al., 1999, Campbell, 1975). Two researchers would not develop the same results, as much depends on an individual judgement of the analyst.

Another defect is that cluster identification methods are not operable. They do not provide information with respect to the existence of agglomeration externalities or market failures. But, unless such indications are made, public policy does not know where interventions may be justified.

By reviewing the empirical literature on agglomeration forces we have learned that an appropriate way of measuring these forces is by relating indicators for its sources with firm performance measures. However, these contributions have again be 'top-down' or 'bird's eye view' type of studies, that did not look into specific clusters. Hence, we have next turned to 'bottom-up' cluster case studies. While qualitative case studies have not contributed much to our understanding of how to identify a specific cluster, we have learned the following insights from a quantitative case study of Sivitanidou (1999): First, primary survey data is essentially required in order to arrive at meaningful answers to our questions. Second, the relevance of the sources of agglomeration forces can be quantified with the help of indirect Likert-scale indicators. However, having a different research aim he did not relate these indicators to firms' performance.

We proceeded by offering an empirical approach to the identification a specific cluster. Thereby we have addressed and attempted to resolve the following measurement difficulties.

First, in order to detect a collection of spatially concentrated firms of related industries the analyst needs to determine a *cluster search area*. Moreover, in order to analyse whether or not agglomeration forces are exclusively at work in a specific cluster, or whether they are operating via different channels, one needs to refer to a control group of firms that show a considerable smaller geographical concentration. In addition, firms in the cluster group and in the control group need to be comparable with respect to key firm characteristics. We have shown how both groups can be identified.

We have identified a cluster search area using a location quotient among other (*top-down*) as well as relevant lists of firms that are considered potential cluster firms (*bottom-up*). In contrast to I/O methods we have not only used suppliers lists that represented I/O linkages. We have additionally suggested to employ other types of firm lists that may capture other linkage types relevant to a cluster. Specifically, a list of (R&D) cooperation partners has been added to our data base. It is assumed to represent linkages that may give rise to knowledge spillovers. Eventually and in contrast to many I/O methods no arbitrary cut-off criterion was needed, rather all potential cluster firms have been identified by use of a *self-selection criterion*. Firms that have participated in the survey have arguably signalled their interest in the cluster and have hence been considered potential cluster firms.

Second, appropriate measures needed to be found for each of the various agglomeration advantages, which were put together in a survey designed for telephone interviews. We used Likert-scale indicators for each relevant type of inter-firm linkages and product and process innovation counts based on the definition of the Mannheim Innovation Panel.

Third, the geographical scope of the cluster needed to be identified. We have argued that it is appropriate to define the geographical boundaries endogenously by letting firms decide themselves what other relevant firms and institutions are nearby.

Fourth, we have shown how to collect primary firm data, by offering a survey that is specifically designed for these purposes.

Once the data are collected, the analyst can conduct both a descriptive as well as an econometric investigation. The former focuses on the question to what types of inter-firm linkages that may generate agglomeration advantages proximity matters. Positive results may indicate the existence of a potential cluster, only. The latter investigates what agglomeration forces (rivalry, demanding customers and/or knowledge flows) may be operating as measured by a significant impact on firms‘ innovation performance. If such an effect can be detected, we may well speak of a cluster. Hence, this approach can be used to distinguish potential clusters, or co-locations of inter-linked firms, from clusters, in which agglomeration forces are in fact generated and exploited.

This approach has been applied to the aeronautic cluster in the Northern German region. Results have suggested that geographical proximity is relevant and statistically significant for only a few types of linkages that may lead to the following effects: labor market pooling, knowledge spillovers, Porter-like motivational effects that stem from customers‘ pressure as well as trust-based effects. These results suggest that these firms constitute a potential cluster, as proximity matters for at least these types of cluster-specific linkages. In order to find out whether or not it is in fact a cluster we have conducted econometric analysis. This investigation has shown that cluster firms benefit from nearby rivals as well as ’other firms’ with respect to inter-firm knowledge flows, whereas rivalry and demanding customers have no positive impact. However, cluster firms do not benefit exclusively from geographically proximate sources of knowledge, but also from distant ones. And surprisingly, our results do not indicate that localized advantages are restricted to the cluster group of strongly concentrated aeronautic (supplying) firms, because certain effects can be found in the control group of spatially dispersed aeronautic (supplying) firms, too.

So our results suggest that agglomeration forces are at best operating weakly. Unless other agglomerative advantages exist that may directly affect productivity or profitability of firms, which have not been analyzed here, the aeronautic (supplying) firms in Northern Germany constitute at best a weak cluster. Rather these findings suggest that it is a strong co-location of firms with an aeronautical affinity that are, however, hardly inter-linked such that agglomeration forces are generated and exploited.

The merits of this approach are related to the fact that it may resolve a number of measurement difficulties. First, it offers a survey which allows to collect detailed firm-level data as an alternative to publicly available sector-level data. Secondly, this survey comprises appropriate measures of the various types of inter-firm linkages that may generate agglomeration advantages. Thirdly, we have shown ways to determine the geographical boundaries endogenously, rather than assuming that they are identical to political boundaries as was the normal procedure in precedinging studies. Fourthly, we have offered a concept to analyse cluster firms in relation to a control group. Lastly, the data collected can be used not only for descriptive but also for econometric analysis, in order to analyse whether or not the group of firms studies constitutes either a cluster or only a potential cluster.

However, the approach is not without problems. Most notably, the surveying of firms is costly. However, given the lack of relevant secondary public data the researcher has arguably no choice but to use primary survey data, in order to arrive at meaningful answers to our questions. Secondly, we have presented results on the impact of three forces on firms‘ innovativeness. Additionally, we have analysed the impact on labor productivity as a proxy for total factor productivity. However, we did not get any reasonable results. In principle, this would allow us to investigate the impact of other agglomeration forces, too, which – theoretically speaking – may not have a direct impact on firms‘ innovativeness but on firms‘ productivity. Furthermore, agglomeration forces may have an impact on firms‘ profitability, too. However, finding measures that firms‘ are willing to hand out seems to be hardly feasible. Thirdly, the surveyed data remain a collection of individual evaluations. So interpretations of our results need to take note of problems related to this fact. If two different people of the same firm are asked the same questions then chances will be high to get two different answers. However, the usage of Likert scales constitutes a standard tool in empirical research. And we believe the data gathered for this analysis leads to more insightful results compared to similar analysis that would use official statistics.

Taken together, this empirical approach to the identification of a specific cluster is arguably less arbitrary than preceding ‘bottom-up’ cluster case studies. In contrast to other cluster identification studies, it is complete and theoretically consistent, because all constituent aspects of the cluster phenomenon, the geographical as well as the functional dimension, may be captured in an adequate way. Moreover, it is an operable approach, because market failures due to agglomeration externalities may be analysed. It may hence provide indications for public policy with respect to where intervention may be justified. Thus, this approach may arrive at meaningful and detailed answers compared to preceding cluster identification techniques.

For future research fruitful work can be expected from comparative cluster analysis, because the findings may have more general implications compared to case studies of single clusters. For such efforts, we herewith would like to encourage a higher degree of standardization in cluster-analysis. This dissertation offers an empirical approach that arguably may contribute to this aim. It has been designed to identify specific clusters and to measure the agglomeration forces irrespective of specific industries. It can immediately be adopted to such purposes (Our survey can be taken from Appendix 2).[72]

[72] An English version of the survey can be sent upon request: lublinsk@econ.uni-hamburg.de.

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Appendix 1

Table 24: Number of Innovations in the years 1999-2001 (Cluster firms and Control group)

	Frequency (relative)		
Cluster-Firms	All Innovations	Product Innovations	Process Innovations
0	15 (0.136)	34 (0.309)	35 (0.318)
1 to 3	25 (0.227)	33 (0.300)	42 (0.382)
4 to 6	27 (0.245)	15 (0.136)	19 (0.173)
7 to 9	10 (0.091)	3 (0.027)	1 (0.009)
10 to 12	7 (0.064)	11 (0.100)	5 (0.045)
13 to 15	10 (0.091)	2 (0.018)	2 (0.018)
> 15	16 (0.145)	12 (0.109)	6 (0.055)
Maximum	200	200	50
Mean	12.11	8.34	3.88
Standard Dev.	24.79	23.19	7.02
Control group	All Innovations	Product Innovations	Process Innovations
0	12 (0.176)	21 (0.309)	22 (0.324)
1 to 3	10 (0.147)	18 (0.265)	19 (0.279)
4 to 6	13 (0.191)	11 (0.162)	12 (0.176)
7 to 9	6 (0.088)	3 (0.044)	0 (0.000)
10 to 12	10 (0.147)	6 (0.088)	10 (0.147)
13 to 15	5 (0.074)	5 (0.074)	1 (0.015)
> 15	12 (0.176)	4 (0.059)	4 (0.059)
Maximum	160	150	50
Mean	12.40	7.32	5.07
Standard Dev.	22.13	19.10	8.03

Note: Relative frequencies are reported in parantheses. Number of observations: 178.

Table 25: Descriptive statistics: cluster and control group

	Cluster Group	**Control Group**
	Mean (STD)	Mean (STD)
KNOW (proximity)	1.88 (1.234)	1.90 (1.138)
KNOW (distant)	1.54 (1.189)	2.21 (0.975)
RIVAL (proximity)	2.75 (2.144)	1.72 (2.014)
RIVAL (distant)	2.05 (2.040)	1.91 (2.057)
DPULL (proximity)	4.37 (1.765)	3.65 (2.204)
DPULL (distant)	3.91 (2.074)	4.66 (1.532)
RD	7.79 (19.458)	11.89 (43.117)
SALES	23.96 (67.61)	23.34 (50.84)
AEROSHARE	40.21 (40.71)	35.23 (37.26)
AGE	34.54 (40.867)	32.57 (42.597)
DENSITY	1175 (960.4)	1027.(871.9)

Notes: RD denotes the number of R&D personnel, SALES are the sales in million Euro, AERO-SHARE is the share of sales with aeronautic products in total sales, AGE is the age of the firms and DENSITY is the population density (population per km 2) of the region where the firm is located. Standard deviations are reported in parantheses. Number of observations: 178.

Appendix 2

Universität Hamburg

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STRATEGISCHE CLUSTER-ANALYSE DES LUFTFAHRTSTANDORTS HAMBURG / NORDDEUTSCHLAND

Wettbewerbsvorteile im Cluster

Betriebsbefragung

Im Auftrag der

Wirtschaftsbehörde der Freien und Hansestadt Hamburg

Worum es geht:

Die höchste Wachstums-, Innovations- und Beschäftigungsdynamik findet man weltweit in regionalen Clustern.[73] Deshalb hat die Wirtschaftsbehörde der Freien und Hansestadt Hamburg in Kooperation mit den bedeutenden Luftfahrtunternehmen der Region Herrn Prof. Dr. Wilhelm Pfähler und Herrn Dipl. Vw. Alf Erko Lublinski von der Universität Hamburg mit einer **Strategischen Cluster-Analyse des Luft- und Raumfahrtstandorts Hamburg / Norddeutschland** beauftragt.

Die Studie dient dem Ziel, den Luft- und Raumfahrtcluster Hamburg / Norddeutschland im Detail kennen zu lernen, weltweit bekannter zu machen und als Cluster weiter zu entwickeln. Zu diesem Zweck

1) soll ein möglichst *vollständiges Bild* des Clusters mit seinen *gegenwärtigen räumlich nahen Beschaffungs-, Absatz-, Informations- und Kooperationsnetzwerken,* den *gegenwärtigen Lücken* und *Engpässen* und den *strategischen Unternehmensplanungen* in diesen Netzwerken gewonnen werden;

2) auf dieser Grundlage sollen *Entwicklungspotentiale* und *Handlungsoptionen* für eine *synergetische, cluster-orientierte Unternehmens- und Wirtschaftspolitik* heraus gearbeitet werden, die den Unternehmen Aussicht auf Investitions- und Beschäftigungschancen bieten *("synergetic growth"*).

Worum wir Sie bitten:

Ihr Betrieb wurde für eine Befragung ausgewählt, weil Sie entweder zur norddeutschen Luft- und Raumfahrtindustrie gehören oder ihr zuliefern. Wir bitten Sie, diesen Fragebogen so genau wie möglich auszufüllen und im beigefügten Kuvert bis **Freitag, den 22. Juni 2001** zurückzuschicken an: *Herrn Lublinski Institut für Allokation und Wettbewerb, Universität Hamburg, Von-Melle-Park 5, 20146 Hamburg.* Auf Wunsch erhalten Sie die wichtigsten Ergebnisse dieser Umfrage.

Was mit Ihren Angaben geschieht:

Die Gutachter (Prof. Dr. W. Pfähler und Dipl.Vw. A. E. Lublinski) tragen die volle datenschutzrechtliche Verantwortung. Alle Ihre Angaben werden streng vertraulich, entsprechend den gesetzlichen Bestimmungen zum Datenschutz behandelt. Das bedeutet, daß alle erhobenen Daten nur in anonymisierter Form, d.h. ohne Namen und Adresse, und nur zusammengefaßt mit den Angaben der anderen Betriebe ausgewertet werden. Die Ergebnisse lassen keine Rückschlüsse darauf zu, welcher Betrieb welche Angaben gemacht hat. Mit anderen Worten: Der Datenschutz ist voll und ganz gewährleistet.

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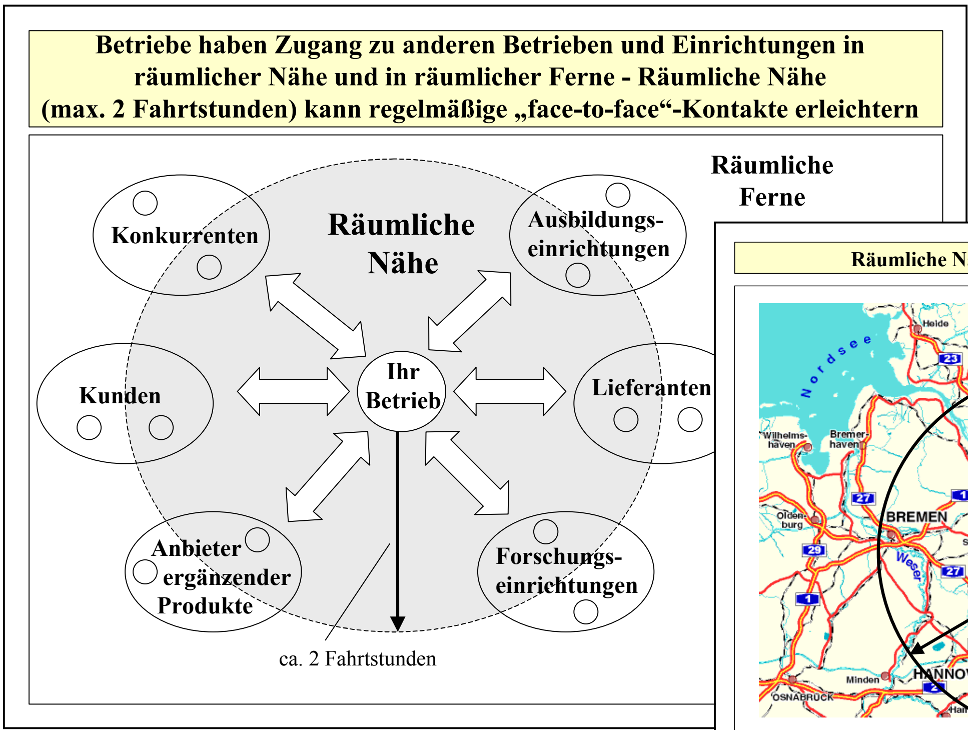
[73] Unter einem Cluster versteht man mit Michael Porter (1999)eine räumliche Konzentration von mit einander verbundenen Unternehmen und Institutionen in bestimmten Wirtschaftszweigen. Zu dem Unternehmensumfeld in einem Cluster gehören eine oder mehrere vernetzte Branchen, Zulieferer von Materialien, Komponenten, Maschinen, Dienstleistungen und Informationen, direkte Anbieter, die sich über die gesamten Vertriebskanäle abwärts erstrecken, „seitliche“ Anbieter von Komplementärgütern und –dienstleistungen, Anbieter aus verwandten Branchen, die gleiche Kanäle, Technologien, Wertschöpfungsaktivitäten und spezialisierte Inputs benutzen, Anbieter finanzieller Dienstleistungen (Banken, Versicherungen, Anteilseigner etc.), Anbieter spezieller Infrastrukturleistungen, öffentliche und halb-öffentliche Institutionen (z.B. Aus- und Weiterbildungstätten, Forschungs- und Entwicklungsinstitutionen, technische Unterstützung wie Testlabors und standard- bzw. normsetzende Instanzen), Unternehmensverbände, Vertreter der Arbeitnehmer und politische Instanzen.

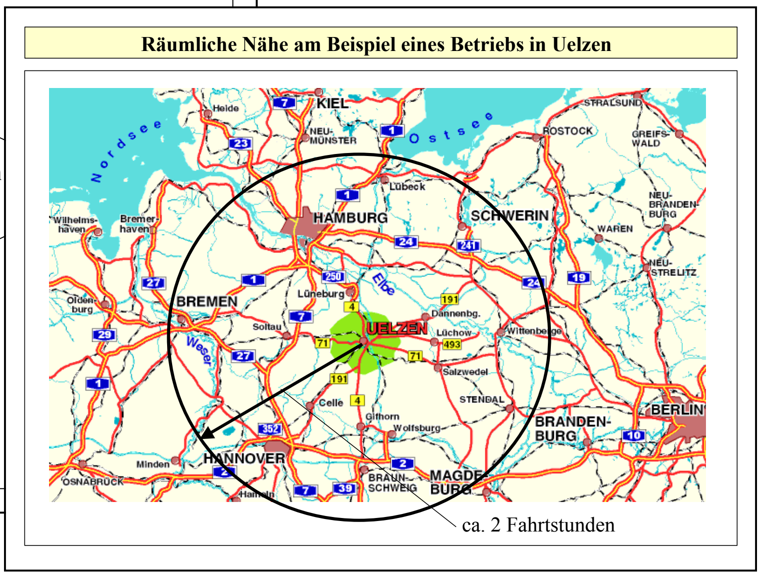
Die Bedeutung der räumlichen Nähe zu anderen Betrieben und Einrichtungen

Wir würden gerne mehr darüber erfahren, welche Bedeutung die **räumliche Nähe** Ihres Betriebs zu anderen Betrieben und Einrichtungen für Ihren Geschäftserfolg hat. Im Folgenden werden wir deshalb systematisch zunächst nach Ihren Verbindungen zu **räumlich nahen** Betrieben / Einrichtungen und dann nach Verbindungen zu **räumlich fernen** Betrieben / Einrichtungen fragen.

Zu Ihrer Information:

*Unter **räumlicher Nähe** wird eine geographische Distanz verstanden, die **häufige und regelmäßige „face-to-face"-Kontakte** erlaubt. Räumlich nahe Betriebe und Einrichtungen sind deshalb in der Regel **bis zu etwa zwei Fahrtstunden** von Ihrem Betrieb **entfernt**. Räumlich ferne Betriebe und Einrichtungen sind mehr als zwei Fahrtstunden entfernt.*





1. Anzahl räumlich naher Betriebe und Einrichtungen

Bitte schätzen Sie die Anzahl der für Sie relevanten Kunden, Lieferanten etc. (siehe nachstehende Liste), die sich in Ihrer **räumlichen Nähe** befinden (bis max. 2 Fahrtstunden entfernt).

- Anzahl räumlich naher Kunden: _____
- Anzahl räumlich naher Lieferanten: _____
- Anzahl räumlich naher Konkurrenten: _____
- Anzahl räumlich naher Fachhochschulen: _____
- Anzahl räumlich naher (technischer) Universitäten: _____
- Anzahl räumlich naher außer-universitärer Forschungseinrichtungen: _____
- Anzahl räumlich naher, relevanter Kammern, Verbände, Behörden: _____
- Anzahl räumlich naher, relevanter Messen, Ausstellungen, Kongresse in 2000: _____

2. Transportkosten (im Rahmen der Beschaffungs- und Absatzlogistik)

Der Anteil der Transportkosten an den Gesamtkosten kann von verschiedenen Faktoren abhängen: u.a. von der Lieferdistanz, der Häufigkeit der Lieferungen an einzelne Kunden oder von einzelnen Lieferanten sowie von Anforderungen an Lieferflexibilität und Pünktlichkeit (Just-In-Time).

2.1. Bitte bewerten Sie unter Transportkosten-Gesichtspunkten die vergleichsweise kurze Distanz zu Ihren **räumlich nahen Kunden** auf einer Skala von 1 (völlig unwichtig) bis 6 (sehr wichtig).

1 2 3 4 5 6
□...□...□...□...□...□

2.2. Bitte bewerten Sie unter Transportkosten-Gesichtspunkten die vergleichsweise kurze Distanz zu Ihren **räumlich nahen Lieferanten** auf einer Skala von 1 (völlig unwichtig) bis 6 (sehr wichtig).

1 2 3 4 5 6
□...□...□...□...□...□

3. Zugang zu Lieferanten

3.1. Wie groß ist schätzungsweise der Anteil der Vor- und Zwischenprodukte, die Sie von Lieferanten in Ihrer **räumlichen Nähe** beziehen: _____%

3.2. Wie spezialisiert sind die Produktpaletten / das Dienstleistungsangebot Ihrer Lieferanten im Durchschnitt? Bitte bewerten Sie den Grad der Spezialisierung dieser Lieferanten auf einer Skala von 1 (breites Produktspektrum) bis 6 (hoch spezialisiert)

	1 2 3 4 5 6
räumlich nahe Lieferanten	□...□...□...□...□...□
räumlich ferne Lieferanten	□...□...□...□...□...□

4. Kundenansprüche

4.1. Wie viele Ihrer Kunden haben sich schätzungsweise aufgrund ihrer Qualität, Innovativität, Schnelligkeit, Kosteneffizienz etc. auf dem Weltmarkt durchgesetzt? Bitte geben Sie die Anzahl dieser Betriebe an:

räumlich nahe Kunden: _______
räumlich ferne Kunden: _______

4.2. Haben Sie den Eindruck, daß Sie von den Ansprüchen dieser global tätigen Kunden stark gefordert werden? (Skala von 1 (völlig unzutreffend) bis 6 (sehr zutreffend))

	1 2 3 4 5 6
räumlich nahe Kunden	□...□...□...□...□...□
räumlich ferne Kunden	□...□...□...□...□...□

4.3. Falls zutreffend, haben Sie den Eindruck, daß die Notwendigkeit zur Erfüllung dieser Anforderungen Ihnen geholfen hat, andere Kunden zu gewinnen?
(Skala von 1 (völlig unzutreffend) bis 6 (sehr zutreffend))

	1 2 3 4 5 6
räumlich nahe Kunden	□...□...□...□...□...□
räumlich ferne Kunden	□...□...□...□...□...□

5. Rivalität / Benchmarking

Die MitarbeiterInnen Ihres Betriebs können ihre berufliche Leistung vergleichen mit der beruflichen Leistung von MitarbeiterInnen anderer Betriebe. Bei den anderen Betrieben kann es sich um direkte Wettbewerber, Kunden, Lieferanten oder branchenfremde Betriebe handeln.

5.1. Mit wie vielen Betrieben und Ihren MitarbeiterInnen vergleichen sich Ihre MitarbeiterInnen aktiv hinsichtlich ihrer beruflichen Leistungen? Bitte geben Sie die Anzahl dieser Betriebe an:

räumlich nahe Betriebe: _______
räumlich ferne Betriebe: _______

5.2. Für wie bedeutend halten Sie diese Vergleichsmöglichkeiten bzw. den Wettbewerb mit anderen Betrieben und deren MitarbeiterInnen für den Arbeitsansporn bzw. die Motivation Ihrer MitarbeiterInnen? Bitte beurteilen Sie diese Bedeutung auf einer Skala von 1 (völlig unwichtig) bis 6 (sehr wichtig).

	1 2 3 4 5 6
räumlich nahe Betriebe	□...□...□...□...□...□
räumlich ferne Betriebe	□...□...□...□...□...□

6. Angebot von Komplementärgütern

Zu Ihrer Information: Produkte oder Dienstleistungen werden häufig zusammen mit sogenannten **komplementären,** also ergänzenden, spezialisierten Gütern oder Dienstleistungen von den selben Kunden nachgefragt. **Beispiele** für Komplementärgüter sind u.a. mechanische Blechbehandlung, -Montage, Streckziehen, chemisches Abtragen, Spare Support, Dokumentation, Wartung. Sie werden alle von den selben Kunden nachgefragt, hier Hersteller des Flugzeug-Strukturbauteils Zelle/Rumpf.

6.1. Schätzen Sie bitte, wie viele Betriebe für Sie relevante Komplementärgüter /-dienstleistungen anbieten:

Anzahl **räumlich naher** Anbieter von Komplementärgütern: ______
Anzahl **räumlich ferner** Anbieter von Komplementärgütern:______

6.2. Kooperiert Ihr Betrieb mit diesen Anbietern z.B. in F&E, Fertigung, Marketing oder Vertrieb?

räumlich nahe Kooperationen Ja....□ Nein....□
Falls ja, mit wie vielen? _____

räumlich ferne Kooperationen Ja....□ Nein....□
Falls ja, mit wie vielen? _____

7. Zugang zu technischem Wissen außerhalb Ihres Betriebs

Betriebe können bei Produkt- und Prozeßinnovationen Zugang zu technischem Wissen von anderen Betrieben und Einrichtungen haben. Dieser Zugang kann Ergebnis sein von informellem Austausch technischen Wissens, gemeinsamen Entwicklungsteams, vertraglich vereinbarten F&E-Kooperationen, Joint Ventures u.ä.

7.1. Welche Bedeutung hatten die folgenden Kunden, Lieferanten etc. (siehe nachstehende Liste) in den Jahren 1997-2000 als externe Wissensquelle für Ihre **Innovationsaktivitäten**? Bitte beurteilen Sie diese Bedeutung auf einer Skala von 1 (sehr gering) bis 6 (sehr groß).

	Kein Wissens-Austausch oder nicht existent	sehr gering 1	2	3	4	5	sehr groß 6
• Räumlich **nahe** Kunden	□	□	□	□	□	□	□
• Räumlich **ferne** Kunden	□	□	□	□	□	□	□
• Räumlich **nahe** Lieferanten	□	□	□	□	□	□	□
• Räumlich **ferne** Lieferanten	□	□	□	□	□	□	□
• Räumlich **nahe** Konkurrenten	□	□	□	□	□	□	□
• Räumlich **ferne** Konkurrenten	□	□	□	□	□	□	□
• Sonstige räumlich **nahe** Betriebe mit relevanter Technologie	□	□	□	□	□	□	□
• Sonstige räumlich **ferne** Betriebe mit relevanter Technologie	□	□	□	□	□	□	□
• Räumlich **nahe** Fachhochschulen	□	□	□	□	□	□	□
• Räumlich **ferne** Fachhochschulen	□	□	□	□	□	□	□
• Räumlich **nahe** (technische) Universitäten	□	□	□	□	□	□	□
• Räumlich **ferne** (technische) Universitäten	□	□	□	□	□	□	□
• Räumlich **nahe** außeruniversitäre Forschungseinrichtungen	□	□	□	□	□	□	□
• Räumlich **ferne** außeruniversitäre Forschungseinrichtungen	□	□	□	□	□	□	□
• Räumlich **nahe** Kammern, Verbände, Behörden	□	□	□	□	□	□	□
• Räumlich **ferne** Kammern, Verbände, Behörden	□	□	□	□	□	□	□
• Räumlich **nahe** Messen, Konferenzen, Ausstellungen	□	□	□	□	□	□	□
• Räumlich **ferne** Messen, Konferenzen, Ausstellungen	□	□	□	□	□	□	□

7.2. Für wie groß halten Sie umgekehrt die Gefahr des unkontrollierten Abflusses Ihres Wissens an andere Betriebe? (Skala von 1 (sehr gering) bis 6 (sehr groß))

	1	2	3	4	5	6
räumlich nahe Betriebe	□	□	□	□	□	□
räumlich ferne Betriebe	□	□	□	□	□	□

8. Zugang zum Arbeitsmarkt

Betriebe brauchen qualifizierte MitarbeiterInnen, die sie von Berufs- und Hochschulen oder von anderen Betrieben rekrutieren können.

8.1. Wie bedeutend waren für Ihren Betrieb die folgenden Einrichtungen und Betriebe bei der Einstellung neuer MitarbeiterInnen in den Jahren 1997-2000? Bitte bewerten Sie diesbezüglich die folgenden Einrichtungen und Betriebe auf einer Skala von 1 (völlig unbedeutend/irrelevant) bis 6 (sehr bedeutend).

	völlig unbedeutend/ irrelevant 1	2	3	4	5	sehr bedeutend 6
• AbsolventInnen räumlich **naher** Berufsschulen	□	□	□	□	□	□
• AbsolventInnen räumlich **ferner** Berufsschulen	□	□	□	□	□	□
• AbsolventInnen räumlich **naher** Fachhochschulen	□	□	□	□	□	□
• AbsolventInnen räumlich **ferner** Fachhochschulen	□	□	□	□	□	□
• AbsolventInnen räumlich **naher** (technischer) Universitäten	□	□	□	□	□	□
• AbsolventInnen räumlich **ferner** (technischer) Universitäten	□	□	□	□	□	□
• Ehemalige MitarbeiterInnen räumlich **naher** Lieferanten	□	□	□	□	□	□
• Ehemalige MitarbeiterInnen räumlich **ferner** Lieferanten	□	□	□	□	□	□
• Ehemalige MitarbeiterInnen räumlich **naher** Kunden	□	□	□	□	□	□
• Ehemalige MitarbeiterInnen räumlich **ferner** Kunden	□	□	□	□	□	□
• Ehemalige MitarbeiterInnen räumlich **naher** Wettbewerber	□	□	□	□	□	□
• Ehemalige MitarbeiterInnen räumlich **ferner** Wettbewerber	□	□	□	□	□	□
• Ehemalige MitarbeiterInnen räumlich **naher**, **anderer** Betriebe	□	□	□	□	□	□
• Ehemalige MitarbeiterInnen räumlich **ferner**, **anderer** Betriebe	□	□	□	□	□	□

8.2. Für wie groß halten Sie die Gefahr, daß Ihre MitarbeiterInnen von anderen Betrieben abgeworben werden? (Skala von 1 (sehr klein) bis 6 (sehr groß))

	1	2	3	4	5	6
räumlich nahe Betriebe	□	□	□	□	□	□
räumlich ferne Betriebe	□	□	□	□	□	□

8.3. Hatten Sie in den Jahren 1997 - 2000 die Gelegenheit, MitarbeiterInnen einzustellen, die zuvor von anderen Betrieben betriebsbedingt entlassen werden mußten?

räumlich nahe Betriebe: Ja....□ Nein....□
Wenn ja, schätzungsweise wie viele? _______

räumlich ferne Betriebe: Ja....□ Nein....□
Wenn ja, schätzungsweise wie viele? _______

9. Vertrauen bei Geschäfts- und KooperationspartnerInnen

Ein vertrauensvolles Klima zwischen Geschäfts- und KooperationspartnerInnen zeigt sich bspw. daran, daß (1.) die PartnerInnen keinen Mißbrauch von Informationen und Wissen befürchten, (2.) auf detaillierte, „rechtssichere" Verträge verzichten können, (3.) nicht befürchten, übervorteilt zu werden oder (4.) sie sich auf die bestmöglichen Anstrengungen der PartnerInnen verlassen können.

Wie stark vertrauen Sie Ihren wichtigsten Geschäfts- und KooperationspartnerInnen?

	nicht existent	1 (sehr geringes Vertrauen)	2	3	4	5	6 (sehr großes Vertrauen)
• Wichtigste(r) **räumlich nahe(r)** Kunde(n)		☐	☐	☐	☐	☐	☐
• Wichtigste(r) **räumlich ferne(r)** Kunde(n)		☐	☐	☐	☐	☐	☐
• Wichtigste(r) **räumlich nahe(r)** Lieferanten		☐	☐	☐	☐	☐	☐
• Wichtigste(r) **räumlich ferne(r)** Lieferanten		☐	☐	☐	☐	☐	☐
• Wichtigste(r) **räumlich nahe(r)** F&E-Auftrag*geber*Innen		☐	☐	☐	☐	☐	☐
• Wichtigste(r) **räumlich ferne(r)** F&E-Auftrag*geber*Innen		☐	☐	☐	☐	☐	☐
• Wichtigste(r) **räumlich nahe(r)** F&E-Auftrag*nehmer*Innen		☐	☐	☐	☐	☐	☐
• Wichtigste(r) **räumlich ferne(r)** F&E-Auftrag*nehmer*Innen		☐	☐	☐	☐	☐	☐
• Wichtigste(r) **räumlich nahe(r)** F&E-KooperationspartnerInnen		☐	☐	☐	☐	☐	☐
• Wichtigste(r) **räumlich ferne(r)** F&E-KooperationspartnerInnen		☐	☐	☐	☐	☐	☐
• Wichtigste(r) **räumlich nahe(r)** PartnerInnen sonst. Kooperationen	☐	☐	☐	☐	☐	☐	☐
• Wichtigste(r) **räumlich ferne(r)** PartnerInnen sonst. Kooperationen	☐	☐	☐	☐	☐	☐	☐

10. Produkt- und Prozeß-Innovationen

<u>Zu Ihrer Information:</u>
<u>Produktinnovationen</u> sind neue oder verbesserte Produkte. Keine Produktinnovationen sind rein ästhetische Modifikationenen von Produkten (z.B. Farbgebung, Styling). Auch Produktvarianten zählen nicht dazu, wenn das Produkt hinsichtlich seiner technischen Grundzüge und Verwendungseigenschaften weitgehend unverändert bleibt.
<u>Prozeßinnovationen</u> beziehen sich auf den betriebsinternen Einsatz neuer oder verbesserter Fertigungs-/Verfahrenstechnik (inkl. Automation) und/oder Fertigungsorganisation.
Neue Produktionsprozesse, die an andere Unternehmen verkauft werden, werden hier als Produktinnovation angesehen.

Wie viele Produkt- und/oder Prozeßinnovationen hat Ihr Betrieb in den Jahren 1999 - 2001 eingeführt bzw. Aktivitäten zur Entwicklung von Produkt- und/oder Prozeßinnovationen durchgeführt?

10.1. Anzahl der Produktinnovationen in den Jahren 1999 - 2001: ________

10.2. Anzahl der Prozeßinnovationen in den Jahren 1999 - 2001: ________

11. Allgemeine Angaben

Bitte geben Sie die folgenden Informationen über Ihren Betrieb an:

11.1. Beschäftigung im Jahr 2000: __________

11.2. Anteil der F&E-Beschäftigten an der Gesamtbeschäftigung im Jahr 2000: _______ %

11.3. Umsatz im Jahr 2000: __________ DM

11.4. Umsatzanteil im Jahr 2000 an Kunden des Luft- und Raumfahrzeugbaus: ________ %

11.5. Brutto-Investitionsausgaben im Jahr 2000: ca.________DM

11.6. Alter Ihres Betriebs: __________

11.7. Namen Ihres Landkreises: __________________________________

11.8. Personalausgaben im Jahr 2000: ca.________DM

11.9. Vorleistungswert im Jahr 2000: ca.________DM

11.10. Bitte benennen Sie Ihr umsatzstärkstes Produkt bzw. -palette: ________________________
____

11.11. Bitte geben Sie an, welchem Wirtschaftszweig das Statistische Landesamt Ihren Betrieb zuordnet (Bitte fragen Sie gegebenenfalls in Ihrer Finanzbuchhaltung nach!)
Wirtschaftszweig: __________________________________ (5-Stelliger Code: _ _ _ _ _)
Bsp.: Luft- und Raumfahrzeugbau (35300)

VIELEN DANK für Ihre wertvolle Mitarbeit

Wir möchten Sie zum Abschluß noch bitten, Ihren Namen und Ihre Funktion in Ihrem Betrieb zu vermerken:

Name / Funktion: ....

Tel. / Fax / E-Mail: ....

Name des Betriebs: ....

☐ ... Bitte senden Sie mir ein Exemplar der Zusammenfassung der wichtigsten Ergebnisse dieser Analyse an meine E-mail Adresse.

Den ausgefüllten Fragebogen schicken Sie bitte an:

IAW, z.Hd. Herrn A.-E. Lublinski, Universität Hamburg, Von-Melle-Park 5, 20146 Hamburg

Curriculum Vitae

Date of birth: 10th September 1972

Education:

- DIPLOM, University of Hamburg, Department of Economics (Dec. 1998)
- VORDIPLOM, University of Hamburg, Department of Economics (Sept. 1994)
- ZWISCHENPRÜFUNG zum Magister, University of Hamburg, Department of Sinology (Sept. 1994)

Working Experience

May 1999 to Sept. 2002: Wissenschaftlicher Mitarbeiter (Teaching and Research Assistant), Universität Hamburg, Department of Economics

Sept. 1998 to Mar. 1999: Case Researcher, China Europe International Business School (CEIBS) Shanghai and Beijing, P.R.C.

Internships: Bertelsmann (Shanghai), Siemens (Munich), Esso (Hamburg), United Chemical Transport (Hamburg), Ahrenkiel Shipping (Hong Kong), Adra/Unicef (Kigali), Sport1.de (Hamburg).