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# **How inter-firm networks influence the development of agglomerations**

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## **Abstract**

Non-market interactions are increasingly regarded as key explanations for spatial concentration. Consistently, both innovation and local knowledge spillovers play a central role in recent theories of agglomeration. According to these theories, exchange of localised knowledge gives firms an innovative advantage which results in better economic performance. However, it has turned out to be difficult to open the black box of economies of scale using empirical tests.

Since interactions get considerable attention in recent agglomeration theory, social network methods and theory are promising approaches to research spatial agglomerations. Even more so because simultaneously, there is an increasing emphasis on interfirm ties in the network field.

The goal of our research is to explore how interfirm networks influence the development of agglomerations. Firstly we provide a review on network and innovation literature in the field of spatial clusters. Secondly, we discuss measurement issues related to networks and innovation and ways to overcome them. Finally, we present preliminary results of our network study among high tech firms in the Dutch region of Twente.

## **1. Introduction**

Silicon Valley and Baden-Württemberg are famous regional clusters of high tech firms. Their success had a massive impact on their surrounding economies. Many spatial scientists see the vibrancy of local cooperation and sharing of knowledge among firms as the key explanation for the success of these regional clusters.

Governments at all levels, challenged by the consequences of globalization, downsizing and outsourcing, recognize the great chances that new technologies and knowledge intensive labour offer. Innovation is seen an important condition for companies to survive increasing international competition. Encouraged by the proven success of famous of high tech clusters, regional, national and supra-national governments have developed policies to stimulate the development of clusters (Enright & Ffowcs-Williams, 2000).

Two elements are central in their policies. Firstly, cooperation among firms is encouraged by rewarding cooperation in R&D, for example by subsidizing joint projects. Secondly, spatial policies are focused on stimulating growth of certain industries. A measure which is frequently implemented is restricting space for high tech firms on “science parks”. Central idea is that direct vicinity in those parks stimulates cooperation and knowledge sharing. These ideas have their origin in research on regional clusters. However, the knowledge on dynamics within clusters is more limited than one would expect by overviewing the world wide policies in this field.

A regional cluster is a specific type of spatial agglomeration in which firms of related sectors are located in direct vicinity. Firms located in a cluster are generally presumed to be more innovative and competitive than similar firms located outside of a cluster. Several studies of clusters have pointed at local interactions as a critical factor for the success of clusters. Researchers describe how combinations of competition, cooperation, exchange of knowledge and mutual learning make those famous clusters so successful. (See e.g. Saxenian, 1990).

The value of interactions is acknowledged in different fields of spatial science ranging from industrial geography to orthodox economics. Although these theories have different emphasizes, most scientists in this field agree that exchange of localised

knowledge gives firms an innovative advantage which results in better economic performance.

Since interactions get considerable attention in recent agglomeration theory, social network methods and theory are often mentioned as promising approaches to research spatial agglomerations. This is even more the case because simultaneously, there is an increasing emphasis on interfirm ties in the network field.

Despite all this attention to interactions within clusters, it is surprising that so little empirical research is done. It remains unclear in what way firms benefit from their spatial location. Moreover it remains unclear what is the spatial dimension on interactions. Only few studies investigate micro level interactions within clusters using network analysis. Most studies on the benefits of clustering are done on the macro level or describe the development of clusters. Although the success of specific clusters at the macro level is indisputable, the mechanism behind clustering dynamics at the micro level is still unexplained. More knowledge about micro-level dynamics within clusters would help governments in developing successful policies.

### **Aim**

The aim of this article is to assess the spatial relevance of interfirm networks for the development regional clusters. Firstly, we discuss relevant theories on regional clusters and we provide a brief review on relevant network and innovation literature in this field. Secondly, we will explore measurement issues related to networks and innovation and ways to overcome them. Finally, our approach to study cluster and preliminary results of our network study among high tech firms in the Dutch region of Twente.

## **2. Theories on regional clusters**

Traditionally, agglomeration dynamics are explained by urbanization and localization economies. Urbanization economies (Jacobs, 1969) refer to the advantages of a location within a *diverse* agglomeration with a bigger market. The size of this plural market generates more economic activities which is beneficial for all firms within such an Urban area. In our research we focus on *localization* economies. These are the benefits from being located in a regional cluster of related firms (Marshall, 1920). Marshall identified three types of localization economies: Firstly, the benefits of a

pooled labour market, Secondly the availability of specialized inputs and services and thirdly the availability of knowledge spillovers. In recent theories on regional clusters, particularly knowledge spillovers play a central role.

Orthodox regional economists like Krugman research agglomeration externalities using “*Simple, stylized models designed for tractability rather than realism (..)*” (Krugman, 2004). Krugman argues that knowledge flows cannot be explained by economic analysis:

*“ (...) Knowledge flows, (...) are invisible; they leave no paper trail by which they can be measured and tracked, and there is nothing to prevent the theorist from assuming anything about them that she likes. (...) I would like to get as far as possible with drab, down-to-earth economic analysis before turning to the other social sciences”* (Krugman, 1991, pp. 53-54)

Economists have made progress in extending models by including spillovers and social interactions as external effects, and by using agent based modelling techniques (Grevers, 2007). However, in these models localized knowledge is still treated as a local public good which is non-excludable. As a consequence, those methods don't reveal the micro mechanism behind clusters. A different approach is necessary achieve this.

Other economists *do* see ways to analyze local spillovers using econometric modelling techniques. (Audretsch & Feldman, 2003) They regard patent citations as the paper trail of knowledge spillovers and prove in their research that knowledge spillovers are highly localized. (Jaffe, Trajtenberg, & Henderson, 1993).

Researchers in other fields within spatial science focus more on innovation and use case study methods to investigate spatial clusters. According to those researchers, local interactions give firms an innovative advantage, which results in better economic performance (e.g. Porter, 1990). They describe the relation between localization, cooperation, learning and innovation using several concepts: Regional innovation systems (e.g. Cooke, 2002), Localized learning (e.g. Maskell, 2001), Regional learning (Florida, 1995) and Innovative milieus (Breschi & Lissoni, 2001).

According to several authors, there is evidence of territorial embeddedness as a source of innovation and competitiveness (Cooke, 2002); (Hess, 2004). Sorenson (2003) These theories all recognise the value of non market relations and argue that knowledge can be both technical and tacit but can both be crucial for the success of firms. Especially for tacit knowledge face to face contact is believed to be important

(Storper & Venables, 2004). Face to face contact would increase mutual trust and enhance open communication and sharing of advice. This kind of resources would make it possible to identify new opportunities in a market.

### **Networks and clusters**

Although the body of research on clusters and innovation is not homogeneous, An increasing number of studies uses network theory and concepts (Peck, 2005). The importance of social values like trust and reciprocity for sharing resources in networks is widely accepted (Dahl & Pedersen, 2004; Morrison & Rabellotti, 2005; Obstfeld, 2005; Rosenfeld, 1997; Uzzi & Spiro, 2005).

Networks are seen as channels for the exchange of knowledge and information and other resources. Ideas and information can be shared more easily between agents in the same neighbourhood than between firms which are dispersed (Gordon & McCann, 2000) (Audretsch & Feldman, 2003). It is concluded that social networks are more easily maintained and established in direct proximity.

The increased attention for networks can be understood by an increasing attention for organizations, management, entrepreneurship and intra- and inter-organizational ties within the network field. This focus makes networks an interesting concept for other research fields. Network ties are for example recognised as a resource of “social capital” (Burt, 1995, 2005; Lin, 1999; Mouw, 2003). The dependent variables that are used in network studies also attract attention of researchers of various fields. Examples are: Innovation (Burt, 1992; Granovetter, 1983) markets (Podolny, 2001; White, 2002) and performance of firms (Uzzi, 1996).

Another theory from the network field that is often cited in other studies, is embeddedness. (Granovetter, 1985) This concept indicates that economic relations are embedded in social relations. According to Uzzi (1996), embeddedness has a positive effect on performance of firms through inter-firm resource pooling, cooperation and coordinated adaptation. He argues that embeddedness can also be harmful for success, when embeddedness is too strong. Over-embeddedness could seal a network off from new information. This idea is related to Burt’s (1992) “structural holes” concept. This is the idea that holes between distant parts of a network need to be bridged in order to get access to new information. Organizations with management and collaborative networks that bridge structural holes in their markets seem to learn faster and seem to be more productive (Burt 2004, p.p. 257).

Researchers in the clustering field acknowledge both the negative effects of lock-in situations (as suggested by Uzzi), as well as the positive aspects of translocal linkages (as suggested by Burt). (cf. (Bathelt, Malmberg, & Maskell, 2004; Bunnell & Coe, 2001; E. Giuliani, 2005).

Although a lot of network concepts are used in research on clusters, the number of empirical studies in that field remains small.

### **3. Measuring data**

Despite the popularity of network concepts, the spatial dimension of informal networks among firms is hardly measured. *If* a network dataset is used at all, it often contains data on formal alliances, buyer-seller relations or on patent relations see (Owen-Smith & Powell, 2004). Although *informal* relations are often central in network theories, most of the time, data on *formal* relations is used as a proxy for those social relations in network analyses. Although even this kind of data can give information on the dynamics at a lower level, one should be very careful when interpreting the results.

Examples of sources of data that are used to analyse inter-firm networks are: Data on strategic alliances, patent-data and economic relations.

Some researchers used data on formal cooperation and **strategic alliances** (e.g. Borgatti & Foster, 2003; Gay & Dousset, 2005; Gulati & Gargiulo, 1999; Hagedoorn, Cloudt, & Kranenburg, 2005; Owen-Smith & Powell, 2004). Usually datasets are used that are based on public reports in newspapers and journals. There are two problems with these resources. Firstly, the databases contain a certain selection of alliances, namely the public ones, predominantly set up by larger firms. Secondly, it is not clear to what kind of relations these alliances reflect.

Similar issues apply to **Patent-data**. Again it is important to see what kind of relations patents citations reflect. In some cases patents provide a way to protect knowledge instead of sharing it. There can also be all kinds of strategic reasons to apply for a patent. However, the most important issue relates content of the relations that are derived from patent data.

It is not clear to what extent a patent citation reflects a real relationship. Patents are cited in a similar way as citations in scientific papers. In those papers, cited publications aren't necessarily written by close contacts. In patent documents, the citations refer to relevant other patents as well. Whether those citations reflect actual relationships is questionable. See Breschi, Lissoni and Montobbio (2005) for an extensive and critical review on knowledge spillovers and patent data.

Other researchers use **economic transactions** to measure interorganizational ties. Uzzi (1996), for example, used this kind of data. In his research on embeddedness, data on the volume of exchanges between contractors and manufacturers was used. His reasoning was that repeated exchange reflected embedded relations. Interviews that he conducted confirmed this assumption (Uzzi, 1996). Other researchers also used network analysis to analyze input-output style data (see e.g. Nakano, 2005).

Although these studies use data on formal networks their approach can be useful in revealing the advantages of being located in a certain area. The data can for example show to what extent a firm is embedded in the regional economy.

### **Exchange of knowledge**

An increasing number of studies uses a direct approach to investigate informal inter-firm relations. e.g. Uzzi and Lancaster (2003). They use analyse networks in which information is exchanged among firms (Bell, 2005; Dahl & Pedersen, 2004; Ingram & Roberts, 2001; Zaheer & Bell, 2005). An example is research by Giuliani and Bell (2005). They collected network data at the firm level in three wine-clusters. They collected data on exchange of: advice, technical support, and on business interactions.

Analysis of the same data by Morrison and Rabellotti (2005) showed that there is a large difference between networks of *less formal* information and networks in which *formal* knowledge was exchanged. Information about new business opportunities, new sellers or providers, new inputs or machineries was easily accessible by almost everyone in the cluster. However, *formal* knowledge, was exchanged in a different way. This type of knowledge was only shared within a strong network that was relatively closed. Firms *outside* this strong connected network were more innovative than firms within the network, because they were more open to external sources of knowledge (E. Giuliani & Bell, 2005; Morrison & Rabellotti, 2005).

At the same time, the importance of cluster is contested. Johansson and Quigley (2004) argued that network ties between firms “*may lead to precisely the same external benefits that arise from agglomerations and for precisely the same reasons*”. In their view networks may substitute for proximity. Giuliani’s (2005) research confirms this. Her research showed that *access to information* is essential. This access to information need not be local and can be obtained via distant network ties. (Gordon & McCann, 2000; Johansson & Quigley, 2004).\_We agree that more attention should be paid to the content of ties and on the type of resources that are exchanged between contacts.

However, it remains an interesting question what is the spatial dimension of more tacit knowledge. Since the dependent variable in most studies is related to technical innovations, studies often focus on the dispersion of technical knowledge and leave out other resources that could be valuable.

Researchers should not only be careful when investigating the content of ties. In order to overcome bias caused by case selection (Appold, 1995; Wiig & Wood, 1995), it is also necessary to conduct a study also among firms in the same sector outside of a cluster or among firms of a different sector.

### **Our approach**

In our view, networks give a further contribution to the analysis of clusters at the micro-level. We argue that a pragmatic, more explorative approach is needed in order to better understand the phenomenon of clustering. In our view the scope of research on clusters should be broadened and not only focus on exchange of knowledge or formal resources and innovation, but investigate the various mechanisms that could effect the performance of firms within clusters.

Only by using this pragmatic, more explorative approach, the black box of regional clusters can be opened. Then it will also become more clear what policies are needed to stimulate regional development. We argue that by choosing this approach, we can better answer the following questions:

- To what extend do related firms cooperate in networks?
- What is the regional dimension of these networks?
- How important are contacts across regions?
- Is it possible to increase performance by stimulating network building?



More specific, we argue that a combination of different sources of data should be used when studying clusters. We argue that in order to investigate clustering mechanisms thoroughly, interview or survey methods should be used as well. By doing that, results that are based several sources of data can be taken together and can be compared. As a consequence, the negative effect of measurement issues can be reduced.

#### **4. Case: High tech in Twente region**

We will give a short description of case-study we are currently doing in the Dutch region of Twente. First we will introduce the Region we are studying. Then we will describe the approach we use and how we try to avoid the earlier mentioned issues. Finally we will present some preliminary results of our network data on membership of professional clubs.

##### **Case: high tech firms in the Dutch region of Twente.**

The case we are currently researching is the high tech sector in Twente.

Twente is an old industrial region in the Netherlands that used to have world's second biggest cotton industry (after Manchester). After the decline of this industry, the Dutch government tried to stimulate economic development. A technical university was founded and, in various ways, entrepreneurship in high tech firms was stimulated. Although the university certainly had a positive impact on the local economy and the number of firms around the university has increased, it is questionable if the region benefits from real cluster-effects. There are some successful firms, among which some of the best performing Dutch high tech start-ups, but a lot of other firms remain small. We hope to find out if firms benefit from other firms in vicinity and in which ways.

##### **Method**

The objective of our research is to map the network among firms. Therefore we are collecting data both on formal and on informal relationships among firms. We use a semi-structured interview approach to investigate the contacts that managers of firms have, both inside and outside the region. We enrich the data with secondary data on

patents, data of the chamber of commerce, for example on turnover, data on formal cooperation and data on membership of professional clubs.

In the Twente region we collect data on networks among high tech firms. Later we will do the same in another, less technical and less clustered sector within the region. By doing this we can examine the differences between them. One of the resources we use in our analysis is data on membership of professional clubs and formal cooperation among firms. The idea is that contacts within such a club can provide firms with information and tacit knowledge.

Although the results are still preliminary and are still being analysed, we show the first results of one of the additional sources of data: the data on professional boards and clubs.

### **Data**

Firstly, we collected data on professional boards and clubs in the region of Twente. For this, we selected general clubs and clubs in the field of technology, but excluded specific clubs that were for example meant for shop owners. This resulted in a selection of 20 Clubs that turned out to have 1551 members (see figure 1).

A first analysis of the two-mode network data (firms\*clubs), showed that the average geodesic among the members of the network (geodesic= average shortest path between 2 random members) is 1.68, which means that in 1.68 steps any other member or club can be reached. This seems quite densely connected. However, we don't have the data of other regions, so we cannot draw any conclusions.

Figure 1. Business clubs in Twente and their members (2-mode network)

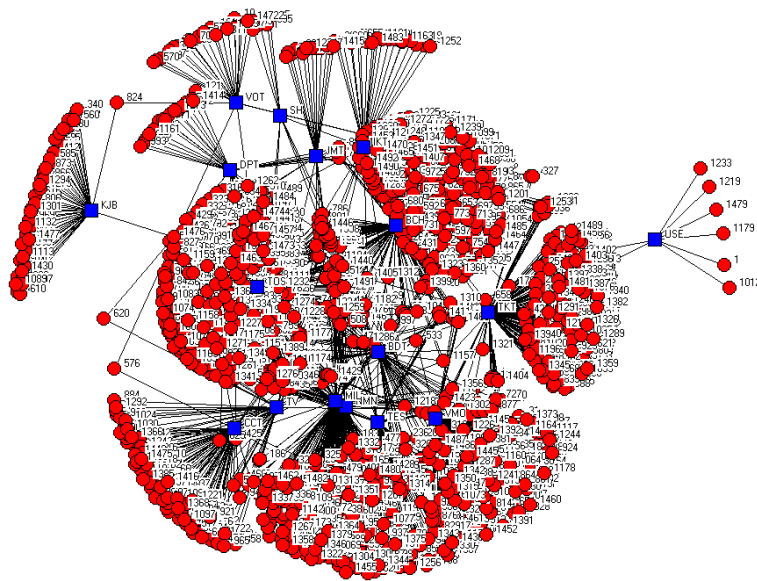


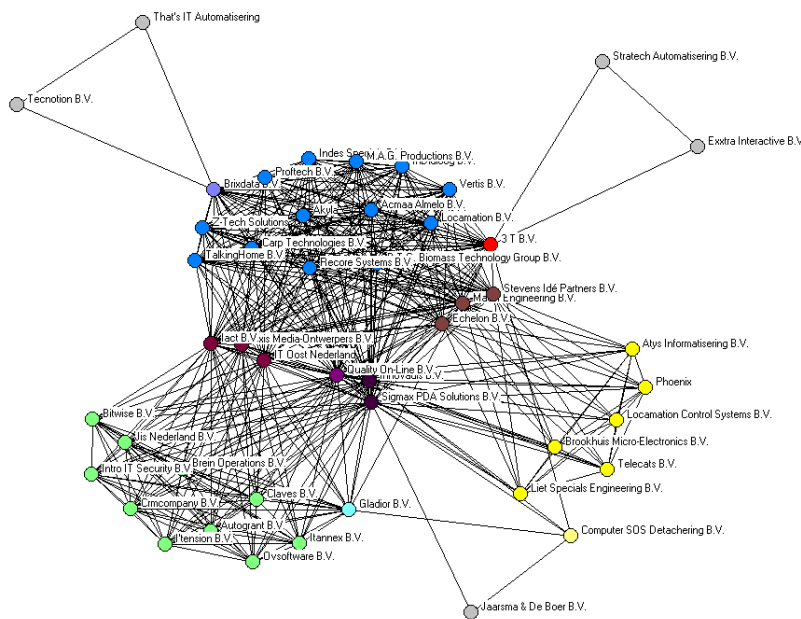
Table 1. Business clubs in Twente and their members

NR of clubs:	20 clubs
NR of members	1551 firms
NR of memberships	1951
density	0.46
Average geodesic	1.68
Diameter	8 (steps)

Our second approach was different. In order to find out how important club membership is for firms in the high-tech sector, we selected all firms within R&D and ICT, with 4 or more employees. For those 176 firms it was checked if they were a member of any organization. The resulting two-mode (firms\*clubs) network was transposed into a one-mode network (figure 2). Figure 2 shows that firms have different positions in the network. Some firms are more central than others.

However, since the networks in figure 1 and 2 are based on 2-mode data, we must be careful while interpreting the analysis. For example, membership of a large club will give a firm a more central position and a lot of ties, while the contacts in a smaller club might be more important for the firm but will give a firm a more peripheral location in the network diagram.

Figure 2. Sample 2 : Network firms in R&D and ICT sector (transposed into one-mode network)



### Results R&D and ICT firms

Total	176 firms
Member of business club	48 (29%)
Not a member	128 (71%)
Diameter	3 (steps)

Further analysis is needed to investigate the collected data. However, ultimate goal is to find out whether the ties in the network among firms based on club data, match contacts that are mentioned in the structured interviews.

## 5. Conclusion

The aim of this article was to assess the spatial relevance of interfirm networks for the development regional clusters. Although the amount of research on clusters has been increasing, understanding the mechanisms behind clustering dynamics has turned out to be difficult. In spite of this, policymakers all over the world try to enhance the development of clusters, although knowledge on clusters is limited.

In the first part of this paper, we discussed theories on regional clusters and networks. We agree that networks can provide an interesting approach in studying clusters. According to clustering theories, exchange of localised knowledge gives firms an innovative advantage, which results in better economic performance. Research indicates that, especially for the exchange of more informal types of knowledge, proximity does matter. We argue that Network analysis can be helpful to make explicit how such informal information is exchanged in clusters.

Secondly we discussed several issues that should be taken into account when researching clusters. One should for example be careful in selecting sources of data and cases, and be cautious in interpreting the results of analyses. To get better insight into the mechanism behind clustering we argued: (1) ..That the focus in studies on regional clusters should be broadened. Research should investigate all benefits from being located in a cluster, not only formal knowledge. (2) ..That Although investigating formal networks can give clues to informal dynamics, to study them thoroughly, interview or survey methods should be used as well. We argued that only by using this pragmatic, more explorative approach the dynamics within clusters can be revealed.

In the final part, of the paper we presented the approach we use in studying our case of high tech firms in the Dutch region of Twente. This was followed by some preliminary results of our network study among region of Twente.

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