Join the Club!

Knowledge Spillovers and the Influence of Social Networks on Firm Performance

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JOIN THE CLUB!

KNOWLEDGE SPILLOVERS AND THE INFLUENCE OF SOCIAL NETWORKS ON FIRM PERFORMANCE

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Chapter 1: Introduction

1.1 JOIN THE CLUB!

Given the financial crisis of 2008 and the related economic downturn, the question of how to stimulate the economy has never been more relevant. A recent article in *The Financial Times*[1] illustrates the relevance of networking in times of economic crisis:

> "Remaining calm and flexible is key to success in a downturn, according to our experts. Duncan Cheatle, founder of The Supper Club, an entrepreneurs' networking group: 'There are a few common factors among our members that are growing fast. Typically they will have a more innovative business model, so in a downturn they are growing market share while the incumbent is struggling. Flexibility is also important. Our members tend to be self-made, and having built their businesses from scratch, they have learnt to be more flexible. If their businesses are still small they can also be more nimble than their competitors. People that have risen up through a company to lead it tend to try to do the same thing as before when things get tough. They don't see what is coming ahead so their businesses start to struggle. The third thing is that our guys tend to be better networked. Better business owners tend to invest time meeting people. In the corporate world, people will have their existing relationships with suppliers and customers but won't actively work their network and seek out new inspiration'."

This newspaper article illustrates why networking activities are generally believed to strengthen a firm's capabilities. Entrepreneurs carry out many kinds of networking activities: they discuss things at business meetings, and members of business associations jointly visit other firms, etc. Speculating about this, in normal economic times, it is seen that entrepreneurs use these activities to improve their businesses and stimulate development.

In times of economic downturn, it comes down more to survival. In such times, discussing and developing new business opportunities is especially crucial. Some

[1] In: Financial Times (London, England) August 23, 2008, London Edition 1, *Don't Panic; ASK THE EXPERTS*, By Jonathan Moules, p. 30.

companies do not focus on immediate business opportunities, but wait out the recession, using this time to develop new products to keep up-to-date and to be ready to benefit when the economy recovers. Therefore, in addition to networking, many companies recognise the need to remain innovative and keep up with societal trends by, for example, investigating cleaner alternatives to current production methods. Large firms such as Toyota may start to downsize, but they also continue to invest in innovation because, as with many other companies, they want to benefit from increasing consumer interest in cleaner technologies. "After the current shakeout is over, the winners in the industry most likely will enjoy a period of brisk growth as consumers satisfy pent-up demand for cars and seek out the latest fuel-saving technologies", said Gary A. Williams, chief executive of wRatings Corp[2].
Innovation has generally been fashionable for the last 20 years. Governments look at the economic and intellectual power of regions such as Silicon Valley with envy and want to replicate this kind of spatial cluster. One recognised characteristic of Silicon Valley is the strong influence of inter-firm networking (Saxenian, 1990). Therefore, strengthening local networks is often seen as a policy tool that can be utilized to stimulate local economies.

The Dutch economic policy agenda, "Pieken in de Delta," aims to strengthen existing regional successes, rather than spending money on regions that are lagging behind (Ministry of Economic Affairs, 2009). One of the policies in this agenda is to stimulate cooperation among universities, research institutes, and firms within regions, thus enabling so-called "knowledge spillovers". In addition to the regional development agencies that work to achieve these goals, the Ministry of Economic Affairs created a government agency, Syntens, designed to stimulate innovation in small- and medium-sized firms. "Syntens is a specialist in all types of innovation, and knows where knowledge and networks can be found" (Syntens, 2009).

The belief that knowledge spillovers tend to have a spatial dimension has inspired many researchers and policymakers in the last few years. Although many aspects of knowledge spillovers have been researched, many things remain unclear. The main issue is how the macro-level success of regions such as Silicon Valley can be understood through micro-level mechanisms. Often, localized knowledge spillovers are seen as determining factors that occur through social relationships. However, it

[2] Quoted in: The Washington Times (USA) December 14, 2008, *U.S. automakers face consolidation,* By Patrice Hill, p. 1.

remains unclear whether and *how* social relationships enable these spillovers. This study attempts to shed some light on the issue by investigating knowledge spillovers through social networks.

1.2 BACKGROUND

Challenged by the consequences of globalization, downsizing, and outsourcing, governments at all levels recognize the great opportunities that new technologies and knowledge-intensive labour offer. They see innovation as an important factor that can contribute to companies' abilities to survive increasing international competition (Porter & Stern, 2001).

Innovation is no longer seen as a process of purely internal research and development (R&D) (Rogers, 1995). Rather, the innovation process is seen as an iterative process in which knowledge is cooperatively exchanged and developed (Von Hippel, 1994). Social networks play an important role in this process because they enable the diffusion of innovations through society (Rogers, 1995).

Innovation is not only studied at the firm level. Spatial scientists see local cooperation and knowledge-sharing among firms as both the most important form of spillover and as the key explanation for the success of clusters (e.g. Saxenian, 1994). Social (or non-market) interactions are seen as the key mechanisms driving the success of spatial clusters (Glaeser, 2000).

Here, a key assumption is that firms inside a spatial cluster perform better than others because they benefit from local knowledge spillovers. Inter-firm networks are often perceived as the pipes and prisms through which local knowledge spillovers occur (e.g. Zaheer & Bell, 2005).

As a result, knowledge spillovers among firms are often seen as economic growth drivers. Encouraged by the proven success of famous high-tech clusters, regional, national, and supranational governments have designed policies to stimulate the development of such clusters (Enright & Ffowcs-Williams, 2000).

Another reason for the prominence of clustering policies at all levels of economic policymaking has been Michael Porter's (1998) promotion of clusters as policy tools. According to Martin and Sunley (2003), policymakers all over the world adopted these clustering ideas. Today, policymakers in many countries and regions are interested in stimulating the development of innovative clusters (Hospers, 2006).

Policies differ greatly, ranging from high-tech cluster development in large cities to the development of rural clusters based on agriculture (Cooke, 2001; Martin & Sunley, 2003; McCann & Folta, 2008; Rosenfeld, 2001).
Two elements seem to be central in the related government policies. First, regional development agencies encourage cooperation among firms by rewarding cooperation among firms—for instance, by subsidizing joint R&D projects (Cooke, 1992). Other cooperative activities that can be stimulated include joint marketing, production, problem solving, and purchasing (Rosenfeld, 2001).
Second, spatial policies focus on stimulating the growth of certain industries. A frequently seen policy is reserving space for high-tech firms in "science parks". The idea is that the physical closeness of firms in these parks will stimulate cooperation and knowledge sharing.

The degree to which spillovers work at the micro-level is not fully understood and there is a rather limited amount of firm-level evidence on the effects of agglomeration economies in general, and local knowledge spillovers in particular (Henderson, 2007). In other words, it is not certain whether, and under what conditions, local interactions lead to enhanced firm performances.

1.3 RESEARCH AIM

The main aim of this research is to open the "black box" of knowledge spillovers by testing the extent to which social interactions among firms in a region contribute to their performance. As such, the research question is phrased as follows:

Research question

Are inter-firm linkages a mechanism for knowledge spillovers?

To answer this question, established network methodology is applied in two novel ways. First, network data based on cooperative patenting (co-patenting) are utilized. Second, network data are derived from business association memberships. Both approaches have been tried before, but they have never been applied on a large scale and have never included firm performance measures. Cooperative patenting (in co-patents) involves cooperative R&D and is a rather formal, rather complex, and hard-to-access type of cooperation. Membership of business associations, on the other hand, is less formal and easier to establish.

Here, the impact of both types of networks on firm performance is studied in an attempt to uncover the micro-foundations beneath local knowledge spillovers.

Figure 1. Example of a Science Park

1.4 OUTLINE OF THE STUDY

The outline of this dissertation is summarized as follows:

Chapters 1 to 6 discuss existing research in the field of spatial clusters, knowledge spillovers, and social networks. In Chapter 2, spatial economic theory is outlined and an important component is the discussion about spillovers as a public good as against generating individual competitive advantages. In Chapter 3, the existing research is discussed with a focus on typologies and ideal types in research on spatial clusters. The Marshall-Jacobs controversy concerning the constitution of economic activity is discussed, and also the debate on the role of geographical scale in knowledge spillovers. In Chapter 4, the micro-macro problem on how to link macro-phenomena to micro-behaviour is discussed. Chapter 5 considers the discussion as to whether social capital should be viewed as an individual or as a collective resource. Chapter 6 discusses social network methods and theory, and the advantages of specific locations in a network such as a bridging one.

Chapter 7 introduces the empirical part of the study and contains the research design and hypotheses. The following chapters consider the research design and the collection of data (Chapter 8), the research model and operational measures (Chapter 9). The results are presented in Chapter 10 and conclusions drawn in Chapter 11.

Chapter 2: Spatial Economic Theory

2.1 AGGLOMERATIONS

Agglomerations are spatial-bounded concentrations of economic activities and serve as relevant phenomena for policymakers and scholars because labour and capital are heavily concentrated in cities, and specific industries are often more likely to be concentrated in certain regions than evenly spread over a country (Rosenthal & Strange, 2004). The concentration process of related industries is often called: "clustering". Especially knowledge-intensive industries, where knowledge is generated through industry R&D, university R&D, and skilled labour are likely to cluster in space (Audretsch & Feldman, 1996; Markusen, Hall, & Glasmeier, 1986).

Several famous high-tech regions have developed swiftly over the last decades. Some examples are Silicon Valley (USA), Emilia-Romagna (Italy), Baden-Württemberg (Germany), and the Cambridge region (England) (Gordon & McCann, 2005). Many scholars relate spatial agglomerations like these to economic growth (Fujita & Thisse, 2002, p. 389), as well as to the innovation and competitiveness of high-tech firms (Audretsch & Feldman, 2004; Duranton & Puga, 2004, p. 2098).

The success of Silicon Valley and Emilia-Romagna in particular are often linked to the extensive networks of regional knowledge exchange. However, many of the studies linking success to networks are anecdotal in nature. Despite increasing efforts to understand the micro-foundations of these successful regions, much remains unknown about the mechanisms that underlie the success of these regions.

2.2 KNOWLEDGE SPILLOVERS

Marshall (1920) identifies three benefits of localized economies that serve as driving forces behind agglomerations: the advantage of a pooled labour market, the availability of specialized inputs and services, and the possibility of knowledge spillovers. He is often referred to as the scholar who originated the idea of knowledge spillovers. Despite a vast body of literature on the relationship between knowledge spillovers and economic growth, there is little evidence on how these spillovers occur. In this respect, Henderson (2007, p. 506- 507) argues that "…despite the fact that knowledge spillovers are central to notions of economic growth, technological progress, and the nature and characteristics of cities, research on the nature of such spillovers is surprisingly limited".

One might wonder if face-to-face contact still plays a role now that so much information is available online, in (scientific) journals, or in other documents. Nevertheless, local knowledge spillovers may indeed still play an important role because some knowledge is only available locally. This type of knowledge is known as "tacit knowledge".

2.3 TACIT KNOWLEDGE

Polanyi (1966) already argued that not all knowledge can be codified, and that therefore, it is important to take the tacit side of knowledge into account. Maskell and Malmberg (1999 p. 172) argue that "the more easily codifiable (tradable) knowledge can be accessed, the more crucial does tacit knowledge become for sustaining or enhancing the competitive position of the firm" and that "...the more easily codifiable (tradable) knowledge can be accessed, the more crucial does tacit knowledge become for sustaining or enhancing the competitive position of the firm". Gertler (2003), identifies tacit knowledge as one of the main determinants for the geography of innovative activity.

In elaborating on the local nature of tacit knowledge, Von Hippel (1994) speaks of "sticky knowledge". For close cooperation between firms—for instance, between a production plant and a development lab—a short distance between the two firms reduces the cost of information transfers. Close proximity, in his view, makes it easier to iteratively adjust the product that is under development instead of first formalizing ("unsticking") the knowledge. Face-to face contact thus makes it easier to start a project and adjust and expand it iteratively by utilizing trusted relations and allowing for flexible outcomes.

Here, networks emerge as channels that enable the exchange of the knowledge and information necessary to access resources, based on mutual trust and reciprocity (Dahl & Pedersen, 2004; Giuliani, 2007; Hansen, 1992). Knoben and Oerlemans (2006) argue that the spatial dimension is important because physical closeness facilitates face-to-face contact, which makes it easier for firms to establish and maintain relationships.

Castilla et al. (2000) stress the importance of network contact to ease the labour market through indirect linkages that help to bring together supply and demand.

According to them, these contacts also enhance the capacity to mobilize capital and find reliable information quickly.

2.4 COMPOSITION OF ECONOMIC ACTIVITIES

In regional economics, there is an ongoing debate about how the composition of economic activity influences knowledge spillovers (Feldman & Audretsch, 1999). There are two contrasting views, and this contrast is sometimes called the "Marshall-Jacobs controversy" (Van der Panne, 2004).

In Marshall's (1920) longstanding view on knowledge externalities, firms benefit from a regional, specialized, sector-specific knowledge base. An increased geographic concentration of sector-related firms facilitates knowledge spillovers across these firms, resulting in a positive effect on their performance.

Jacobs (1969), in contrast, stresses the importance of diversity, as it fosters the cross-fertilization of ideas (Rosenthal and Strange, 2004). In Jacobs' view, spillovers between dissimilar firms specifically lead to more innovation and firm growth.

Jacobs (1969) theorises that urbanization externalities refer to the advantages of a location within a diverse urban agglomeration. Industry specialization, in her view, is risky. In one chapter of her famous book "The Economy of Cities", which is titled 'The Valuable Inefficiencies and Impracticalities of cities', Jacobs describes how 'modern', specialized cities like Manchester faced significant problems when their efficient ways of producing spread across the world and their comparative advantage disappeared (Jacobs, 1969).

Both of these views on the effect of the composition of economic activities on knowledge spillovers assert that interactions among firms are an important factor in the exchange of knowledge and information.

2.5 PUBLIC GOOD OR INDIVIDUAL COMPETITIVE ADVANTAGE?

Marshall (1920, p. 271) describes knowledge spillovers as advantages that are "in the air". Therefore, economists concluded that tacit knowledge is a public good, an assumption that is not being researched. Surprisingly, Marshall did not explicitly distinguish the public nature of knowledge spillovers. However, he was probably one of the first who mentioned the individual advantages of interpersonal exchanges and learning: "Good work is rightly appreciated, inventions and improvements in machinery, in processes and the general organization of the business have their merits promptly discussed: if one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of further new ideas" (Marshall, 1920, p. 271).

The public good nature of spillovers

Orthodox economists have adhered to the idea that knowledge spillovers offer a public good advantage. Krugman (1991) was one of the first traditional economists to renew interest in regional agglomerations externalities using "...simple, stylized models designed for tractability rather than realism..." (Krugman, 2004). Krugman argues that despite the decline in transportation and communication costs, distance still plays a very important role (Krugman, 2004).

In locational dynamics models, transportation costs and land rents are often used as explanatory variables. Transportation costs are seen as a cause for concentration and land rents are viewed as a centrifugal force. However, these two factors would result in a relative evenly distribution of land use. This is where economies of scale enter.

"...geographic concentration is clear evidence of the pervasive influences of some kind of increasing returns [spillovers]" (Krugman, 1991, p. 5). In short, economies of scale represent the advantages of being co-located. There must be advantages to being located in a cluster in order to overcome the disadvantages of high land rents and congestion.

The phrase "economies of scale" can refer to either internal or external economies of scale. Internal economies of scale exist when a firm has lower production costs because it can serve a bigger market and therefore produce more efficiently. External economies of scale are advantageous for companies because of their proximity to a main market.

Krugman also cites Marshall's (1920) knowledge spillovers as one of the three reasons for localization. "Evidently forces for localization other than those involving high technology are quite strong...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. A sociologist might be able to help with survey methods; but 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, p. 53-54).

Besides the measurement issues pertaining to knowledge spillovers, Krugman is also sceptical about the importance of knowledge spillovers in general:

"Finally, high technology is fashionable, and I think we are all obliged to make a deliberate effort to fight against fashionable ideas...Of course, the world has changed, but it was a pretty remarkable place before the coming of large-scale integrated circuits, and even high technology industries respond to old-fashioned economic forces".

"So, while I am sure that true technological spillovers play an important role in the localization of some industries, one should not assume that this is the typical reason—even in the high technology industries themselves" (Krugman, 1991, p. 54).

Krugman has the opinion that there are still many questions about clustering mechanisms. However, he prefers to stick to economic methods because, in his view, these methods can best explain clustering. One recent development in this field is the extension of economic models to include spillovers and social interactions as external effects (Becker & Murphy, 2001; Durlauf & Young, 2001; Fujita & Thisse, 2002). Audretsch and Feldman (2004, p. 2719) argue that "social interactions have economic value in transmitting knowledge and ideas". They further state that "tacit knowledge is inherently non-rival in nature, and knowledge developed for any particular application can easily spill over and have economic value in very different applications" (Audretsch & Feldman, 2004, p. 2718-2719).

Spillovers as individual competitive advantages

The assumption that knowledge spillovers lead to public advantages does not discard the possibility of investigating localized networks as competitive benefits for individual firms. If firms benefit individually, localized knowledge spillovers are excludable and therefore not a public good. Boschma and Ter Wal (2007, p. 196) argue that knowledge spillovers are not in the air "...because knowledge tends to accumulate and remain inside the boundaries of firms and networks". If knowledge spillovers are not a public good, but the result of social interactions among firms, firms are the beneficiaries of those interactions (Feldman, 2003).

The network methodology provides a way to empirically investigate the individual advantages of interactions in a network and is seen as a methodology with the strong potential to investigate knowledge spillovers (Ter Wal & Boschma, 2009).

2.6 INTERACTIONS AS MECHANISMS BEHIND SPILLOVERS

Gordon and McCann (2000) link the benefits of localized spillovers to interactions among firms. In Hansen's view (1992), informal relationships can improve access to all kinds of essential resources and facilitate innovation and the creation of new market activities. Face-to-face contact plays an important role in establishing and maintaining these informal relationships. Accordingly, face-to-face contact fosters trust. Trust-based relationships reduce transaction costs since they reduce the risk of opportunism (McCann & Sheppard, 2003). Face-to-face contact is easier to realize when the actors are in close vicinity to one another; proximity makes it easier to start and maintain reciprocal relationships (Glaeser, 2000). This is especially true for the tacit knowledge embodied by high-skilled workers (Storper & Venables, 2004 p. 367). Because tacit knowledge is hard to grasp, it is often seen as an important source of competitive advantage for firms.

Chapter 3: Existing Research about Spillovers

Existing research about knowledge spillovers and clustering can be divided into anecdotal studies and studies that are more empirical.

3.1 Anecdotal approaches to investigate clusters

Saxenian (1990) and Florida (2002) and their followers use an anecdotal approach to investigate spillovers. According to these authors, there is evidence of territorial embeddedness as a source of innovation and competitiveness. They offer in-depth descriptions of how combinations of competition, cooperation, and knowledge exchanges make clusters especially successful (Malmberg & Maskell, 2006).

Marshall (1920) was already a clear supporter of cooperation in business: “Enough has been said to show that the world is only just beginning to be ready for the higher work of the cooperative movement; and that its many different forms may therefore be reasonably expected to attain a larger success in the future than in the past” (Marshall, 1920, p. 307).

Hansen also describes how cooperation and intense competition co-occur. “Paradoxically, both cooperation and competition have been intensifying as local firms learn with their customers, suppliers, and competitors about what to make next and how to make it” (Hansen, 1992, p. 102).

Florida (2002) stresses the importance of the “creative class”, which he sees as an engine for economic development. Creative professionals and knowledge workers, ranging from painters and web designers to chemists and lawyers, belong to this class; in fact, all college-educated workers are part of this class. In Florida’s view, social interactions within this creative class lead to new ideas, innovation, and economic success.

As I discussed earlier, some famous regions, such as Silicon Valley, have proven to be strongly innovative—much more innovative than other regions. Saxenian (1994) analyzes the differences between Silicon Valley and the Route 28 area. While the boundaries between firms and society were blurred in Silicon Valley, the boundaries of companies were strictly defined in the Route 28 region. This difference was also reflected by their production chains. In Silicon Valley, firms specialized themselves,

whereas the Route 28 firms followed the tradition of vertical integration by integrating suppliers (Saxenian, 1994). Saxenian's analyses reveal how social interactions are the explanation for the success of Silicon Valley, compared to the decline of the route 28 region. She describes the specific culture of Silicon Valley, where entrepreneurs see social relationships as a crucial aspect of their businesses. Informal networks provide firms with technical and market information and also function as very effective job search and recruitment networks (Saxenian, 1994).
Business associations played an important role in facilitating this informal network. They not only provided a way to diffuse knowledge about state-of-the art ideas and technologies in design, production, and marketing, but also provided a more formal representation of the firms to the regional government (Saxenian, 1994). Amin (1999) also stresses the importance of participation in associations as an important cultural aspect that explains the success of the Italian Emilia-Romagna region. Castilla et al. (2000) likewise agree upon the importance of associations. They describe how individuals and industries that are not active in the main high-tech industry of Silicon Valley became involved through associations.

Several scholars conclude that there is evidence of local interactions as a source of innovation and competitiveness (Cooke, 2001; Cooke, 2002; Hess, 2004). According to Sorenson (2003), to start a new firm, a potential entrepreneur needs information to find a suitable market niche in order to make profit. Moreover, the entrepreneur needs capital, skilled labour, and knowledge to exploit this opportunity. "Social relationships play a crucial role in acquiring tacit information and in convincing resource holders to join the fledgling venture" (Sorenson, 2003, p. 514).
Sorenson stresses the importance of nearby social contacts (networks), and points out that business contacts follow this pattern. These contacts are important conduits for communication flows (Sorenson, 2003). Saxenian (1994, p. 46) underlines this idea: "the paradox of Silicon Valley was that competition demanded continuous innovation, which in turn required cooperation among firms".

Curran and Blackburn's (1994) research presents completely different results. Based on 400 interviews in seven British regions, this research concludes that the importance of both networks and the region are declining, and that firms have a more flexible way to establish relationships. Those relationships are less often permanent and, because of modern communication equipment, more often conducted at significant distances. However, their view does not receive widespread support in the area of economic geographic research.

3.2 EMPIRICAL STUDIES ABOUT KNOWLEDGE SPILLOVERS

There are more systematic empirical approaches that investigate knowledge spillovers and spatial distribution of industries. About half of them are descriptive, while others link spillovers to firm-level outcomes.

Distribution of knowledge as an indicator of spillovers

Prevezer (1997) studied the location pattern of U.S. Biotech firms and found that this industry is highly clustered in space. Van Oort's (2002b) results were similar. He discovered that innovative activity in the Netherlands, measured with labour costs for R&D, is spatially clustered. This shows that science-based industries are more concentrated than other industries.

Patents are mostly related to knowledge-intensive work and therefore seen as outcome measures for regional innovation. Verspagen and Schoenmakers' (2004) results show that R&D is concentrated in a small number of regions. Therefore, they conclude that regional innovation systems in Europe are still factors in the location decisions of firms. Similarly, Ponds and Van Oort (2008) find that science-based industries are clustered in space, and suggest that this might be a result of the advantages of localized knowledge spillovers. The distribution of patents is therefore often used to identify knowledge spillovers in the spatial distribution of patents.

The consequences of clusters and knowledge spillovers

Studies linking the localization pattern of industries to outcome measures have, until now, shown various effects. Henderson (2003) confirms in his research that high-tech firms benefit in terms of productivity from localization economies (the result of clustering of similar firms). Henderson's (2007) later research confirms these results. Rosenthal and Strange (2003) demonstrate similar outcomes. Based on industry shares of employment and the birth of new firms, they find stronger support for the localization hypothesis than the diversity hypothesis.

Rosenthal and Strange (2003) also find that a positive effect on the diversity of firms is the birth of new firms. This positive effect of diversity is confirmed by many researchers. Glaeser et al. (1992) likewise find that the diversity of firms fosters firm growth at the regional level. They find a negative effect of specialization. Van Oort (2002a; 2007) concludes that Jacobs-related sector variety is the dominant condition for agglomeration externalities in the Netherlands. His analyses are based on data for industrial firms and municipal employment growth. Van Stel and Nieuwenhuijsen confirm these results, just like Feldman and Audretsch (1999), who also affirm the diversity hypothesis and show that diversity in economic activities promotes innovative outputs.

The negative consequences of firms being located in a cluster of related sectors are discovered by Baum and Mezias (1992), who prove that clustered hotels had higher rates of failure than other hotels. Shaver and Flyer (2000) explain this by pointing out that for the best firms in a cluster, the disadvantage of employees moving to small spin-offs is larger than the advantages of agglomerating. Folta et al. (2006) show that there is an inverted, U-shaped relationship between cluster size and firm performance. Another finding was that the larger the size of a cluster, the more likely the firm is to fail (Folta et al., 2006).

On the contrary, Feldman and Florida (1994) confirm that innovation clusters geographically in areas with geographic concentrations of specialized (high-tech) resources. They also found that the spatial concentration of these resources reinforced the innovative capacities of firms. Van der Panne (2004) confirm these results and through their research on new regional product announcements as dependent variables, they show that the Marshall hypothesis holds, especially for R&D-intensive and small firms.

The spatial distribution of knowledge-intensive firms and their patents reflects the spillover phenomenon on the macro-level. It does not provide insight into micro-level exchanges. The previously mentioned results of studies about the Marshall-Jacobs controversy (Van der Panne, 2004) show that the results are not consistent and that studies differ in their approaches. Henderson (2007) points out that: "Despite the fact that knowledge spillovers are central to notions of economic growth, technological progress, and the nature and characteristics of cities, research on the nature of such spillovers is surprisingly limited".
However, instead of testing existing theories and focusing on the micro-level, several researchers followed Marshall's original ideas and developed their own typologies.

3.3 TYPOLOGIES AND IDEAL TYPES

A typology is a summary of the intersections of two or more variables (Babbie, 1998). Ideal types never match reality, whereas on a continuous scale, the dimensions of a typology always match to a certain degree (in this case, for example, the diversity of firms in a region).

The Marshall versus Jacobs discussion is an example of the obscuring use of typologies in knowledge spillover research. Both the Marshall and Jacobs hypotheses are ideal types stressing different aspects that are not necessarily mutually exclusive. They both describe the constitution of regions at the macro-level (Rosenthal & Strange, 2004; Van der Panne, 2004).Rosenthal and Strange (2004) show how the difference between absolute and relative specialization complicates the interpretation of specialization variables. Because a relatively small city size can coincide with a large absolute sector size, different specialization measures generate different outcomes. Duranton and Puga (2004 p. 2110) make a similar point and argue that "It is very difficult to conceive how interactions within 'an army of clones' could generate sufficient benefits to justify the existence of modern cities".

This illustrates that the ideal types of homogeneity and heterogeneity of firms are not sufficient to explain clusters. Therefore, it is important to know what degree of diversity and similarity is important. Researchers could avoid this issue by focusing on the micro-level in order to investigate the two dimensions separately.

Instead of building on existing research and focusing on the micro-level using empirical research, researchers have come up with various "new" clustering concepts at the macro-level. Martin and Sunley (2003) argue that concepts such as: industrial districts, industrial complexes, new industrial spaces, territorial production complexes, neo-Marshallian nodes, regional innovation milieux, technolopoles, technology districts, Italian industrial districts, hub-and-spoke districts, satellite platform districts, hot spots, network regions, sticky places, regional systems of innovation, learning regions, and Porter's competitive diamond are all reinventions of Marshall's ideas and all represent new ideal types (Bunnell & Coe, 2001a; Gordon & McCann, 2000; Markusen, 1996; Martin & Sunley, 2003).

The geographic scale of spillovers

Another issue that remains unsolved is the geographic scale in which knowledge spillovers occur. Suggested scales range from a radius of one mile to cities, regions, states or even countries (Martin & Sunley, 2003; McCann & Folta, 2008). As in the

previous case, knowledge can spill over at short distances and also across large distances. Due to the lack of empirical research, there is little consensus on this issue.
Rosenthal and Strange (2003) show that agglomeration economies of a certain industry are largest in close vicinities, decrease rapidly with the addition of the first few miles and then attenuate much more slowly. They suggest that information spillovers might be responsible for most local advantages because face-to-face contact is important, especially for those types of spillovers.
On the other hand, the advantage of translocal linkages in accessing new information is stressed (Bunnell & Coe, 2001a; Markusen, 1996). Malmberg and Maskell (2006) point out that localized and distant learning are not mutually exclusive. To support the local knowledge spillover hypothesis, they argue that, despite the advantages of distant links, it is not necessary for local interactions to dominate over extra-local links (Malmberg & Maskell, 2006, p. 9).

Again, Johansson and Quigley (2004) adopt a different position. They argue that proximity becomes less important because networks may substitute for proximity. They argue that connections between firms "may lead to precisely the same external benefits that arise from agglomerations and for precisely the same reasons" (Johansson & Quigley, 2004, p. 166).
Giuliani (2005b) shows that access to information is essential and that the local dimension is less important. Appold (1995) confirms this: "...researchers have systematically ignored the possibility that business organizations that have similar internal structures and linkages to other producers but that are not located in dense concentrations might nevertheless be just as productive, innovative, and capable of adjusting their operations to rapidly changing market conditions" (Appold, 1995, p. 28). Oinas (1999) agrees and asserts that learning is the result of a combination of proximate and distant interactions.

When investigating the relevant spatial scale for spillovers, some researchers argue that the geographical dimension of exchange networks among firms should comprise the unit of analysis. Breschi and Lissoni (2001b, p. 270): "These (networks) are likely to be a much more fruitful unit of observation than the region or the state as such, since they are an organisational arrangement that allow firms both to circulate and to internalise many knowledge flows. In particular, an explicit link should be established between the geographical dimension of knowledge flows and the research on all the contractual arrangements that allow firms and individuals to appropriate their knowledge rents, as well as the disclosure rules foreseen in those arrangements".

Gordon and McCann (2000) also see social networks as an alternative to physical closeness. However, in a later study, Gordon and McCann (2005) concluded that there is more support for the orthodox agglomeration effects described by Marshall (1920). In their research, Gordon and McCann find that regional links with customers, suppliers and joint ventures positively affect innovative behaviour. This effect does not differ in the Greater South-East and the Industrial Heartland. The exact way that these orthodox spillovers function, however, remains unclear.

Just like the Marshall-Jacobs controversy, the distinction between local and translocal linkages represents an ideal type distinction. The focus on typologies uses assumed behaviour as a foundation for knowledge spillovers instead of focusing on the micro-level. A region or firm can have a combination of both. Malmberg and Maskell (2006) show that the risk of thinking this way is neglecting to focus on the mechanism driving these typologies.

One of the reasons for the increasing focus on distant ties lies in the nature of the data used to investigate spillovers. Often, large firms are over-represented. This is, for example, the case in databases with strategic alliances based on newspaper articles and annual reports. Because multinationals operate on a larger scale than smaller firms, their cooperative behaviour reflects this scale.

The importance of distant ties does not automatically mean that local ties are unimportant in terms of acquiring knowledge and gaining competitive advantages. If distant ties are an advantage for all firms, than local ties can make a difference by providing an advantage that other firms cannot achieve because they are located further away. Therefore, a more fine-tuned analysis is needed to investigate these local social interactions. To cite Glaeser (2000, p. 104): "We cannot understand cities and agglomerations without understanding nonmarket interactions".

Chapter 4: The Micro-Macro Link

4.1 THE MICRO-MACRO PROBLEM

The question of how to link macro-level phenomena with micro-level dynamics has puzzled many researchers in different fields for some time. Coleman (1990, p. 6) defines the micro-macro problem as: "the problem of moving from the lower level to the system level to explain system behaviour based on actions and orientations at the level below". Coleman (1986) argues that this problem is often misleadingly referred to as "aggregation". For social scientists in general, it is a major challenge to come up with micro-foundations for macro-social phenomena (Van der Veen, 2007).

"In economics, for example, there is microeconomic theory and there is macroeconomic theory; and one of the central deficiencies in the economic theory is the weakness of the linkage between them, a weakness papered over with the idea of 'aggregation' and with a ubiquitous concept in macroeconomic theory, that of the 'representative agent'" (Coleman, 1990, p. 6).

Coleman (1990) stresses the importance of focussing on individual actors to explain macro-phenomena. A macro-level phenomenon is not a simple aggregate of the individual level, but a result of interactions among individual actors. In his well-known "Coleman-Boat", he graphically depicts how the micro- and macro- level can be related (see Figure 2).

Figure 2. The "Coleman-Boat"

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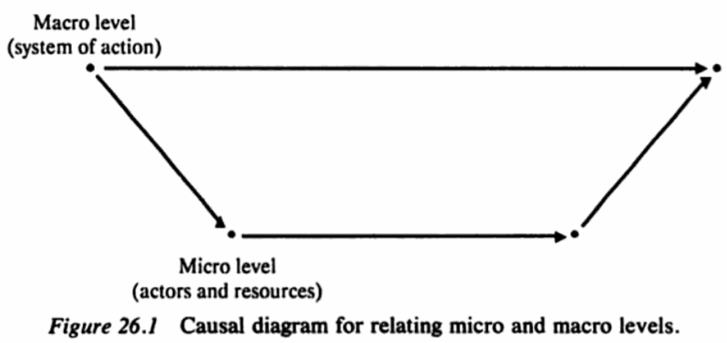


Figure 26.1 **Causal diagram for relating micro and macro levels.**

(Coleman, 1990, p. 702)

Given the increasing computing power of computers, the possibility of examining interdependencies between different levels of analysis has expanded. Multilevel analysis has been developed to investigate the micro-macro problem through regression analysis. Multilevel analysis can be used to assess both the effects on all levels, and the interactions between these levels. Multilevel analysis provides a tool to analyze this link empirically (Snijders & Bosker, 1999). Moreover, multilevel analysis can be utilized as an alternative to aggregation, which is often used in spatial studies.

4.2 THE MICRO-FOUNDATION OF KNOWLEDGE SPILLOVERS

Knowledge spillovers constitute a typical example of the aforementioned micro-macro problem, and the easiest solution for this problem is aggregation of the micro-level. However, it turns out that aggregation does not always lead to correct predictions of macro-level phenomena, and it is not clear what does provide a good prediction. This is a fundamental methodological reason that the micro-foundation behind localized spillovers remains a mystery.

In the last few decades, theoretical constructs such as agglomeration economies and localization have been used by regional economic theorists to explain why firms locate in the vicinity of one another and why, on one hand, they benefit from companies conducting the same types of activities and, on the other hand, also gain "from the general atmosphere in such a region" (Van der Veen & Otter, 2001, p. 147). Despite the development of these constructs, the results of the empirical research based on these constructs has been less fertile, leaving their micro-foundation a black box (Van der Veen & Otter, 2001).

Many social scientists have tried to investigate the missing link between the micro- and macro- levels. A relatively new branch of research that tries to shed light on macro-level changes from a micro-perspective is the study of so-called transitions.

4.3 TRANSITIONS

According to Martens and Rotmans (2005, p. 1136), a transition can be defined as "a gradual, continuous process of societal change where the structural character of society (or a complex sub-system of society) transforms". The term "transition" is sometimes used to describe the desirable development of a more sustainable world. Historic transitions, such as the development of steam technology, are studied to understand the processes behind these transitions (Geels & Schot, 2007). A bottom-up approach is central, wherein cooperative innovation networks at the micro-level develop new (more sustainable) ideas and technologies that—via all kinds of interaction mechanisms—emerge in the form of macro-level changes (Van der Brugge, Rotmans, & Loorbach, 2005). Understanding the success of spatial clusters based on their micro-foundation is therefore one of the themes of transitions research.

The 1987 Brundtland report defined sustainable development as "...development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987, p. 4). Lafferty (2004) describes the interdependencies between the three components of sustainability: the environmental component, the economic component, and the social component, and how policies are developed to decouple economic development and environmental pressures.

The spatial clustering of firms is related to sustainability in two ways. First, it relates to the spatial distribution of welfare. The clustering of economic activities leaves space open in other areas, but also generates negative side effects in the clustered regions—for example, congestion and pollution. The second issue of sustainability is the (social) economic development of peripheral regions. An increased clustering of economic activity can lead to declining welfare in the peripheral regions.

4.4 SIMULATION TECHNIQUES

Squazzoni (2008) argues that simulation methods provide good opportunities to analyze these micro-macro links behind transitions as an alternative to the existing, more descriptive approaches to analyze transitions (e.g. Geels & Schot, 2007).

Simulation techniques are used to try to fill the gap between micro and macro by modelling individual agents. These agents have individual preferences and goals and meet one another with certain possibilities. In this way, these interacting agents create a macro-structure. Due to their utilization of these so-called agents, these simulations are often called "agent-based models".

Using agent-based models to research the micro-foundation of macro-phenomena has become a more prevalent practice in recent decades. Agent-based modelling provides a way to link micro-level behaviour and macro-level phenomena. Moreover, it helps to clarify the connections between different levels of aggregation (Van der Veen & Otter, 2001).

Schelling (1978) already used simulation techniques to investigate the sometimes unpredictable link between micro-motives and macro-behaviour. Using a kind of checker-board approach, he demonstrated how simple individual (discriminatory) preferences resulted in macro-outcomes with patterns of segregation that were not directly linkable to the individual level (Schelling, 1971).

In the wake of Schelling's research, agent-based models have been seen as one of the ways to solve the micro-macro problem in the field of sociology (Sawyer, 2003). Since computation power has increased, it is now possible to simulate processes on a larger scale and with more complex rules. However, the choice of the set of decision rules remains a complex issue in the use of agent-based models. Therefore, according to Van der Veen and Otter (2001), more efforts should be made to investigate the fundamentals of interacting agents. If theory is not used as a starting point for agents' preferences and decision rules, it is likely that simulation results will be arbitrary.

Tesfation (2003) uses agent-based models in economics to model markets. How agent-based models can be used to investigate land use changes as an alternative to the existing economic models is demonstrated by Otter et al. (2001) and Filatova et al. (2009).

Although striking results can be obtained via simulation techniques, some researchers argue that it is important to bear in mind that agent-based models are not meant to model the real world because agent-based models remain computational methods. Grevers (2007, p. 46) argues that "the relation between simulation and computation might be closer than is sometimes claimed in the literature on the use of simulation in the social sciences". Jumping from a descriptive approach to simulations neglects other methods that are more rooted in empirics or theory. Eventually, simulation methods might be useful to investigate alternative scenarios or simulate future outcomes, but should always be based on empirical results or theory.

4.5 SOCIAL NETWORK ANALYSIS

Social network analysis is used to investigate the structure and consequences of social interactions. Social networks are often the unintended effect of individual actions and, as such, can be called a "spontaneous order" (Stokman, 2004). Granovetter (1973) argues that network analysis provides a fruitful micro-macro bridge. "In one way or another, it is through these networks that small-scale

interaction becomes translated into large-scale patterns, and that these, in turn, feed back into small groups" (Granovetter, 1973, p. 1360).
To cite Stokman (2001, p. 10509): "Social network analysis in general studies the behaviour of the individual at the micro-level, the pattern of relationships (network structure) at the macro-level, and the interactions between the two. The analysis of the interaction structures that is involved in social network analysis is an important element in the analysis of the micro-macro link, the way in which individual behaviour and social phenomena are connected with one another".

I argued above that explaining the performance of individual firms in a spatial cluster is the only way to better understand the success of spatial clusters. Moreover, social interactions are central in theories that explain clustering and knowledge spillovers.

A recent body of literature stresses social networks as a way to unveil the micro-mechanism behind knowledge spillovers (Dahl & Pedersen, 2004; Henderson, 2007; Storper & Venables, 2004). To link the micro and macro-levels in this research, I studied the use of social network analysis. In addition, multilevel analysis was used to test this link statistically. The following chapters will further elaborate on the role that social networks and knowledge spillovers play in spatial theories.

The notion that the resources of others can be accessed through social networks lies at the heart of social capital theory. It provides a framework to analyse social interactions in depth. Social network theory is strongly related to social capital. The principle of social capital is that individuals are able to access resources via others. Therefore, it is relevant to study the mechanism behind knowledge spillovers in clusters.

Chapter 5: Social Capital

5.1 INTRODUCTION

Social capital is defined as the advantage people have based on their location in a social structure (Burt, 2004). This "opportunity structure of social relationships" (Stokman, 2001, p. 10510) can be beneficial in several ways. It can for example lead to significant performance benefits for organizations (see Adler and Kwon (2002) for a detailed review).

The social capital concept has had an important impact on spatial cluster research because it often relates to face-to-face contact at a close distance.

Social capital can be distinguished at the group level and at the individual level (Lin, 1999, 2001; Morales & Geurts, 2007). I will discuss the group-level view, then the individual-level view, on social capital. This chapter will conclude with a discussion on trust and reciprocity.

5.2 GROUP-LEVEL SOCIAL CAPITAL

Social capital is often viewed as a group-level concept and regarded as a common pool resource that is freely available to members of a group (Coleman, 1988; Putnam, 1993). The public good aspect of social capital is, in Coleman's view, a characteristic that distinguishes social capital from other types of capital (Coleman, 1990).

Coleman (1990, p. 300) argues that a widely supported misconception has been dominant in society, one implying that "…society consists of a set of independent individuals, each of whom acts to achieve goals that are independently arrived at, and that the functioning of the social system consist of the combination of these actions of independent individuals" (Coleman, 1990, p. 300). Coleman's point is that "…individuals do not act independently, goals are not independently arrived at, and interests are not wholly selfish" (Coleman, 1990, p. 301). Instead, he argues that the social capital concept provides a way to account for social structure. In his view, social capital can take three forms: "obligations and expectations, information channels, and social norms" (Coleman, 1988).

Putnam (1993) introduced a spatial component in his study on Italian regions. He defines social capital as: "features of social organizations, such as networks, norms, and social trust, that facilitate coordination and cooperation for mutual benefit" (Putnam, 1995 p. 67). In a thorough elaboration, Putnam determines that regional success factors are related to social capital, as, for example, might be measured by membership in associations or social clubs. His measures of social capital are highly correlated with good educational outcomes, good health, and good government (Sobel, 2002) and are related to culture and civic involvement.

The value of membership in business associations as an important source of social capital is stressed by many scholars (e.g. Coleman, 1990; Flap & Boxman, 2001; Putnam, 1993). Stolle (1998) relates membership in voluntary organizations to face-to-face contact and trust. Putnam sees the decline of these kinds of societal involvement as a threat to society (Putnam, 2000). Several studies investigate associational involvement to monitor this phenomenon over time (Frane, 2008; Morales & Geurts, 2007).

Group-level social capital at the regional level

Putnam's focus on Italian regions resulted in a number of studies about regional level social capital. Beugelsdijk and Van Schaik (2005, p. 306) tested the generalizability of Putnam's Italian research. They used aggregated active and passive group membership numbers across 54 NUTS 1 regions in Europe (based on the European Values Study). Their main finding was that active membership and regional economic growth are indeed positively related. At the same time, they did not find a positive correlation between passive association memberships and regional-level trust (Beugelsdijk & Van Schaik, 2005). Beugelsdijk et al. (2004) found different results. In a study based on the World Values Survey, they did discover that trust had a positive effect on economic growth.

Because studies like these use aggregated data, it remains hard to discover why trust fosters economic growth case. Therefore, Beugelsdijk and Van Schaik conclude that it is risky to derive direct policy implications and that future research should focus on the mechanisms behind the relationships between social capital and economic growth (2005, p. 322).
A shortcoming of Putnam's approach is that he does not consider the social structure in detail. Some researchers argue that understanding social capital requires a finer-grained analysis at the individual level (Adler & Kwon, 2002). I discuss individual-level social capital in the following paragraph.

5.3 INDIVIDUAL-LEVEL SOCIAL CAPITAL

Most researchers stress the individual nature of social capital. It is usually defined as the individual resources accessible via a social network of direct and indirect contacts (Coleman, 1988; Lin, 2001). The important aspect of this definition is that social capital is *not* a common pool resource, but unit-specific. The most important benefit of social capital is that it facilitates access to information (Adler & Kwon, 2002 p. 29). Therefore, especially for innovative firms, social capital is a crucial source of competitive advantage (Cooke, 2007). The two main elements of individual-level social capital can be distinguished as resources and structural position.

Resources

Researchers who focus on individual resources define social capital as "a combination of the number of people who can be expected to provide support and the resources those people have at their disposal" (Boxman, De Graaf, & Flap, 1991, p. 52). Resources that are often mentioned range from small favours, such as lending a cup of sugar, to providing large financial loans.

Studies in this field investigate different kinds of resources (e.g. Geurts, 1992). The "Resource Generator" by Snijders and Van der Gaag (2005, p. p. 12) provides a good example, with items ranging from "Do you know someone who owns a car?" to "Do you know someone who can give advice on matters of law?" This approach is relevant for knowledge spillover research because it provides ways to investigate direct contacts between entrepreneurs with specific types of knowledge resources. Moreover, it makes it possible to investigate the benefits of access to those resources.

Structural Position

Lin (1999) and Burt (2005) investigated the structural position of actors in social networks. In network theory, not only are direct contacts important, but indirect contacts are just as important to the formation of a network Ahuja (2000). In this approach to social capital research, a score can be obtained for every actor in the network, as opposed to working solely with aggregated scores. Social capital is often used to explain the relative success between individuals and organizations (Borgatti & Foster, 2003). Various researchers have studied how networks influence the innovation of firms (Burt, 1992; Granovetter, 1983), markets (Podolny, 2001; White, 2002), and the performance of firms (Uzzi, 1996).

5.4 TRUST AND RECIPROCITY

Trust and reciprocity are important aspects of social capital. Burt (2001 p. 32) defines trust as: "a willingness to commit a collaborative effort before you know how the other person will behave" (based on Coleman (1990, chapter 5)). According to Gambetta (1988, p. 218), someone is trustworthy when "the probability that he will perform an action that is beneficial or at least not detrimental to us is high enough for us to consider engaging in some form of cooperation with him".

Trust is also related to reciprocity. Hansen (1992 p. 97-98) defines reciprocity as "a mutual expectation or understanding that a given action will be returned in kind". Delayed or generalized reciprocity is an important component of social capital. In this form of reciprocity, a favour is not being returned at the same moment, but at a later point in time. Trust is a prerequisite for these kinds of reciprocity.

Beliefs about trustworthiness are often related to membership in social groups. Members of the same social group (in-group) are often perceived as more trustworthy than other persons (Williams, 2001).

McEvily et al. (2003) see trust as an organizing principle, especially for organizations that are knowledge-intensive or involved in strategic alliances. Those organizations are dependent on and vulnerable to the actions and decisions of others. They describe how trust increases the propensity to share knowledge with others and, at the same time, reduces knowledge screening. From the sender's point of view, trust in a receiver reduces concerns about misuse of the transferred knowledge. From the receiver's point of view, trust decreases the need to verify information, and the receiver can then use the new knowledge more quickly (McEvily et al., 2003).

Therefore, relationships that accommodate trust and reciprocity are less dependent on formal contracts and thus avoid the related transaction costs (Williamson, 1993). As a result, relationships with a foundation of trust and reciprocity enhance cooperation and the exchange of information and knowledge.

Gulati and Gargiulo (1999) describe how cooperations mitigate the uncertainties that dependencies create. This is an important reason for companies to establish such cooperations. In sectors that evolve rapidly, overcoming these uncertainties is very important in remaining innovative (Meijer, 2008).

To investigate trust, several trust measures have been developed. Studies demonstrate the importance of trust as a prerequisite for the successful exchange of resources and information.

Van de Bunt et al. (2005) study the evolution of trust networks within an organization. Davis et al. (2000) found that trust in the general manager increased firm performance.

Other trust studies were externally oriented, focusing on trust relations with customers and suppliers. A close relationship with customers provides firms with essential information to follow a customer's needs in order to sustain the relationship. As a corollary, firms achieve higher (innovative) performance (Doney & Cannon, 1997; Sin et al., 2005). Following the same reasoning, trust relations are also beneficial for relationships that provide firms with the information necessary to follow and sustain relationships with other important organizational stakeholders. Moreover, contacts provide firms with information about (local) market conditions and industry trends (Ingram & Roberts, 2001). All in all, trust is one of the prerequisites for the exchange of information between firms. Therefore, trust relations are important to take into account when investigating knowledge spillovers.

5.5 SOCIAL CAPITAL MEASURED VIA NETWORKS

Individual-level social capital is often measured by an actor's structural position within social networks. Borgatti et al. (1998) discuss relevant network measures to formalize the notion of social capital. In this approach to social capital research, a score can be derived for every actor in the network, rather than working solely with aggregated scores. This focus also improves measurability and avoids obscurities that emerge thorough the use of the word "capital". Kadushin (2004) prefers to replace the social capital concept with the term "networked resources". Going back to the research question, networked resources are the key element of networks as the mechanisms driving knowledge spillovers.

Chapter 6: Social Network Theory

6.1 INTRODUCTION

Social network theory is a theory or method (there is debate about this distinction) that aims to investigate social ties between actors and their resulting macro-structures. Social network analysis has its origin in different strands of research (Scott, 1991b). Moreno (1934) was one of the first researchers to investigate social networks. His study of friendship networks within small groups of individuals and his introduction of "sociometry" to study these networks were important milestones. Sociometry was used mostly to investigate small-scale groups in social psychology, but, over time, it has become a central theme in the field of sociology (Granovetter, 1973). Network research is also deeply rooted in graph theory, a mathematical subfield (Freeman, 1978).

In network theory, not only are direct contacts important, but indirect contacts and overall structures are significant in the formation of networks (Ahuja, 2000; Burt, 2005; Lin, 1999). Accordingly, network contacts not only provide access to their own resources, but also serve as an important source of referrals (Gulati, Nohria, & Zaheer, 2000). The social network field provides methods and theories to investigate resources that are encapsulated in networks.
Since Moreno's implementation of matrices in his sociometric studies, major computational possibilities have become available to investigate social networks (Stokman, 2001), especially for calculating the structural properties of networks, such as centrality. The terminology in network studies is partly derived from graph theory (Freeman, 1978).

Social networks provide a way to investigate the micro-macro link as mentioned in the previous chapter: "A large number of other network studies examine the effects of the network structure on the behavior and attributes of the network members, (and[3]) the effects of the macro-structure on micro behavior." (Stokman, 2001, p. 10510).

[3] Word added

According to Wasserman and Faust (1994), the network perspective is fundamentally different from standard social science research and methods: "Rather than focusing on attributes of autonomous individual units, the associations among these attributes, or the usefulness of one ore more attributes for predicting the level of another attribute, the social network perspective views characteristics of the social units as arising out of structural or relational processes or focuses on properties of the relational systems themselves" (Wasserman & Faust, 1994, p. 7-8).

According to Stokman (2004), the social network concept has developed from a metaphor into a concept with a clear empirical reference. In addition to the often stressed methodological aspect, Wasserman and Faust (1994) emphasize the theoretical side of social networks: "Some authors have seen network analysis as a collection of analytic procedures that are somewhat divorced from the main theoretical and empirical concerns of social research. Perhaps a particular network method may appear to lack theoretical focus because it can be applied to such a wide range of substantive problems from many different contexts. In contrast, we argue that much network methodology arose as social scientists in a range of disciplines struggled to make sense of empirical data and grappled with theoretical issues. Therefore, network analysis, rather than being an unrelated collection of methods, is grounded in important social phenomena and theoretical concepts" (Wasserman & Faust, 1994, p. 11).

Although social network theory focuses mainly on interpersonal relations, various research fields have shifted their attention to social network theories and methods. Borgatti and Foster (2003) and Brass et al. (2004) provide an extensive outline of the research conducted on networks at the interpersonal, inter-unit, and inter-organizational levels of analysis. There are different views on the importance of tie strength and network position in a network.

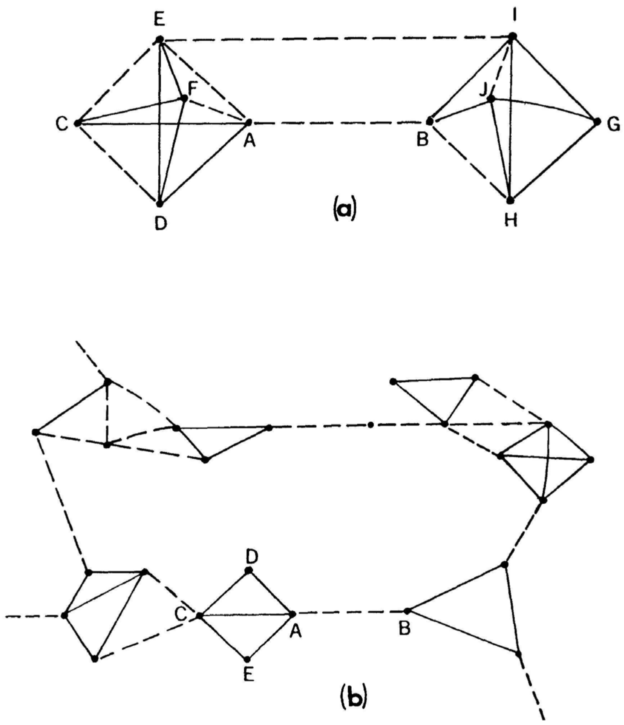
6.2 TIES, BRIDGES, AND INFORMATION BENEFITS

Granovetter (1973) defines tie "strength" as "a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie". Granovetter stresses the importance of weak ties to access new information. Following this definition, a weak tie involves limited contact in time and intensity.

In Granovetter's view, weak ties are important for obtaining new information because close friends tend to move in each other's circles, and information is shared within these circles. These are thus fully interconnected components. New information and opportunities, in his view, must come through the weak ties that connect people in separate components (see Figure 3). The weak ties are therefore a critical element of social structure. Granovetter calls his argument "the strength of weak ties".

Figure 3. Granovetter's Illustration of the Strength of Weak Ties

FIG. 2.—Local bridges.



—— = strong tie; – – – – = weak tie.

(Granovetter, 1973, p. 1354, (legend altered))

In Granovetter's view, weak ties are essential for the connection of further unconnected social clusters in a society (Granovetter, 1983; 2005). It is important to note that according to Granovetter, the weak tie itself becomes important only when it links two separate components.

Burt (1992) came up with the "structural holes" concept. This term refers to the hole that needs to be bridged to obtain novel ideas, information, and resources. The structural hole concept is similar to the "strength of weak ties" argument, but differs in two ways.

The first difference is that Burt does not address tie strength in his ideas. There is a great chance that such ties are weak. This need not be the case, however (see Figure 4 for an illustration). "…the causal agent in the phenomenon is not the weakness of a tie but the structural hole it spans. Tie weakness is a correlate, not a cause" (Burt, 1992, p. 27-28). Moreover, he argues that "by shifting attention away from the structural hole responsible for information benefits, to the strength of the tie providing them, the weak tie argument obscures the control of structural holes" (Burt, 1992, p. 28).

The second difference from Granovetter's ideas is the restriction of the non-redundancy of a bridging tie. According to Burt: (1992, p. 47) "Structural holes are the gaps between nonredundant contacts. As a result of the hole between them, the two contacts provide network benefits that are in some degree additive rather than overlapping. A network optimized for information benefits can be described with respect to its contacts or connections between contacts. A network rich in nonredundant contacts is rich in structural holes". In this way, by means of these bridging ties, information from outside the network can be accessed (Burt, 1992).

Figure 4. Structural Holes and Weak Ties

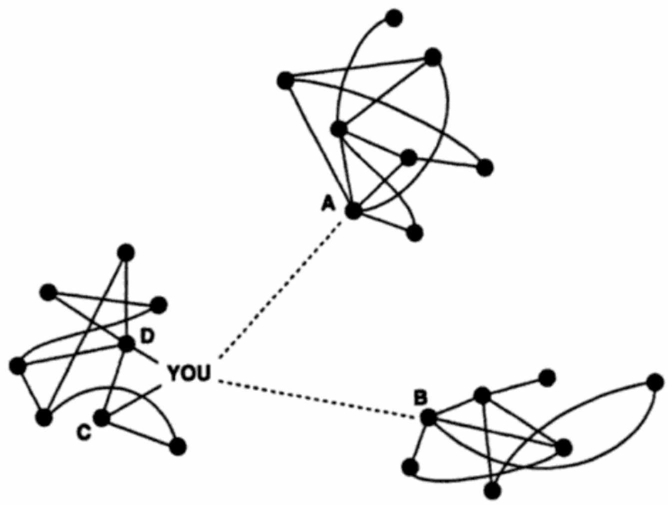


Figure 1.6 **Structural holes and weak ties**

(Burt, 1992, p. 27)

In addition to offering information benefits, structural holes can result in control benefits. "They equip: certain players with an advantage in negotiating their relationships…It is the tertius gaudens, the third who benefits from structural holes: a person who derives benefit from brokering relationships between other players" (Burt, 1992, p. 47).

For the purpose of this study, the important point is that structural holes (or the bridges that span these holes) result in competitive advantages in the form of information benefits. According to Burt (2004), organizations with networks rich in bridges across structural holes are likely to learn faster and be more productively creative.

Coleman (1988) has a different opinion. In his view, strong ties play an important role in social networks. "Dense and strong ties allow for social control, and facilitate the build-up of reputation and social capital, in the form of trust and social norms, which facilitate collaboration" (Coleman, 1988). He also argues that dense social networks are very important because they facilitate the trust that is a prerequisite for the exchange to occur (Coleman, 1990). Because, in his view, information and resources are easily shared in densely connected networks, strong ties are very important.

Although there might be disagreement about how tie strength and structure are important, researchers in the network field agree that it is generally true that ties generate information benefits. Information benefits are of special importance to actors operating in rapidly developing markets and are therefore relevant to this research about knowledge spillovers.

6.3 NETWORKS AND INNOVATION

Information is an important resource that is needed to keep firms innovative. According to Rogers (1995), an innovation is "an idea, practice, or object that is perceived as new by a person or another unit of adoption". Rogers gives an extensive overview of innovation and diffusion literature. He and other researchers (Bunnell & Coe, 2001b; Deffuant, Huet, & Amblard, 2005; Fischer, Suarez-Villa, & Steiner, 1999), stress the importance of social networks for innovation.
Organizations use inter-organizational networks to pool or exchange resources and to jointly develop new ideas and skills (Powell & Grodal, 2005, p. 59). Network analysis has been particularly useful in clarifying both technological and organizational intra- and inter-firm innovation and diffusion.

Social networks can provide companies with new information that can be used to develop new ideas and products. Obstfeld (2005, p. 100) posits that "If combination is the key to innovation, then social network activity may be an important predictor of people's involvement in innovation". Owen-Smith and Powell argue that formal cooperative relations provide access to informal spillovers among firms (Owen-Smith & Powell, 2004).
Various researchers have studied how networks influence innovation (Burt, 1992; Granovetter, 1983). A specific example is Burt's (2004) article on "Good Ideas". Based on a survey of several hundred managers in a large company, Burt proves that "People with connections across structural holes have early access to diverse, often contradictory, information and interpretations, which gives them a competitive advantage in seeing and developing good ideas" (Burt, 2004, p. 388).

Oerlemans et al. (2001) investigated to what extent external factors contributed to the innovation process of firms. Their results show that firms intensively using internal and external resources are more innovative. In their qualitative study, which was based on interviews, Uzzi and Lancaster (2003) found that different types of network ties promote different types of knowledge transfer and learning.

In another study based on the community innovation survey, Faems et al. (2005) investigated inter-organizational collaboration. They concluded that the more organizations collaborate with other organizations, the more likely they are to create new or improved products that are commercially successful.

Ahuja (2000) studied linkages within the chemicals industry using data on technical collaborations—for example, joint ventures and joint research and technology sharing agreements—to investigate the effect of direct and indirect linkages on innovative output, which was measured according to the patent frequency of firms. Ahuja's results revealed that both types of ties have a positive effect on innovation.

Verspagen (2007) used a network approach to investigate flows of patent citations in order to map the evolution of technology fields, "chains of ideas" (2007 p. 98), and related patents over time.

Figure 5. Patent Network Showing the Evolution of Technology Fields

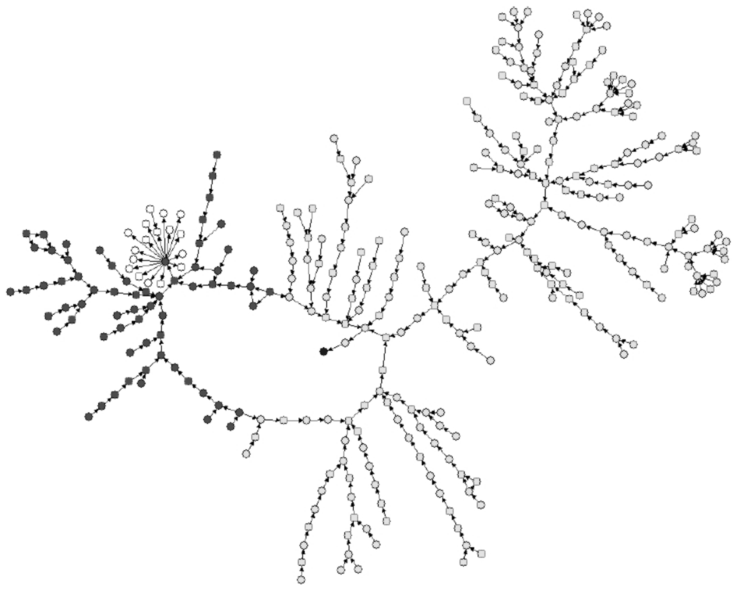


Fig. 2. The largest component in the network of main paths in fuel cell technology, 1860–2002.

(Verspagen, 2007, p. 107)

In addition to offering information benefits, inter-firm networks influence the functioning of markets, according to some researchers.

6.4 NETWORKS AND MARKETS

Podolny (2001) describes the role of networks as "plumbing" the markets. Kalleberg (1995) gives an overview of opportunities for research around the boundaries of sociology and economics. He argues that social networks can be useful to contextualize social exchange and to explain processes operating in labour and other markets (Kalleberg, 1995, p. 1212). Manski (2000) also provides a good overview of the renewed interest of economics in social interactions.

Granovetter (1985), referring to the idea that economic relations are embedded in social relations, came up with "embeddedness" as a new concept. According to Uzzi (1996), embeddedness has a positive effect on performance through inter-firm resource pooling, cooperation, and coordinated adaptation. He argues that embeddedness can also hinder success if it is too strong; over-embeddedness would seal off a network from new information.

Informational cues

According to White (2002), network ties are necessary to obtain a good position in a market, as they can be used for signalling purposes and for determining a market niche. Nakano and White (2007) assess the possible effects of networks on transactions and price formation within a supply chain.

Scientists in the strategic management field acknowledge the value of social relations based on trust. Studies in this field proved the importance of trust as a prerequisite for the successful exchange of resources and information with customers and suppliers (Morgan & Hunt, 1994). Based on the exchange of resources and information, firms achieve higher (innovative) performance (Doney & Cannon, 1997; Sin et al., 2005). For this reason, researchers developed several ways to measure trust within relationships. Referrals are a way for organizations to learn about the trustworthiness of potential partners (Gulati & Gargiulo, 1999, p. 1447).

Podolny explains that the "presence or absence of a tie gives an informational cue about the quality of market actors". A certain firm that is unknown to company "X", but that has many exchange relations with firms trusted by "X", will be regarded as trustworthy sooner than a firm without these ties. Information about quality can be

very important, especially within the services sector, where product comparison is often difficult. In these cases, networks can be very useful.
Networked relations can also be beneficial when dealing with uncertainties. Meijer et al. (2007) investigate how uncertainties influence innovation decisions. One of the approaches to dealing with uncertainties that they describe is information exchange through networks.

A second function of networks, which is described by Granovetter (2005), is to serve as an important source for social reward and punishment. Because information can spread easily through a network, undesirable behaviour can be punished (partly) by exclusion.

Another role of networks is that they provide trust: the confidence that others will do the right thing. Norms—shared ideas about the proper way to behave—are clearer, more firmly held, and easier to enforce, particularly in a denser social network.
As previously outlined, inter-firm network ties can be advantageous in several ways—for instance, as a source of information that is necessary for the development of innovations. Network ties are also relevant in determining market opportunities, assessing the trustworthiness of partners, judging the quality of products, overcoming uncertainties, and determining rewards and punishments. These are the advantages that explain why localized inter-firm ties increase firm performance and are thus a likely source of knowledge spillovers.

6.5 INTER-FIRM NETWORK STUDIES

Descriptive network studies

Dittrich and Duysters (2007) describe the development of the network of R&D cooperations around Nokia. They illustrate that for different strategies, different types of inter-firm networks are needed. Gulati's (1995) findings stress the importance of trust in the development of inter-firm alliance networks. More and more studies are examining the development of alliance networks over time. Gimeno (2004) studies the development of alliance networks in response to the alliance networks of competitors. Another example is Gay and Dousset's (2005) study, which finds that firms with cutting-edge technologies develop ties more rapidly than other firms.

Greve and Salaf (2003) also included a temporal dimension in their study and observed how the social network of entrepreneurs developed over time, with the most networking activity taking place in the planning phase prior to starting up the firm. Other researchers have investigated interlocking boards and directorates as sources of interactions (De Nooy, 2002; Mizruchi, 1996; Scott, 1991a; Stokman, 1973).

Huggins (2001) investigated the role of the managing director in firms. He concludes that they have an important position for developing and maintaining inter-firm networks. Based on his case studies, he also found that trust is a prerequisite for exchange and interaction among firms. One of the ways to build a network is through business association membership.

Rosenfeld (2001, p. 116) describes how management literature has stimulated the role of cooperation and business associations: "Business schools and books...teach managers to 'position their own companies within interlocking business networks' and to use cooperation strategically". Rosenfeld (2001) sees these cooperative organisations as an important means of stimulating innovation and learning.

Porter and Stern (2001, p. 36) also describe the advantages of industry associations. Neff (2005) suggests that networking events within the cultural industry of New York mediate access to important information and resources. Cooke (2007) investigated spatial, professional and business network membership in different UK regions and assessed its impact on three performance measures. His results reveal that high-performance firms seem to be the most intensive users of social capital. Moreover, knowledge-intensive firms were even more engaged in the networks he investigated.

Although the descriptive side of inter-firm networks is an important element for us to consider when investigating knowledge spillovers, linking these networks to outcome measures is more relevant to this research.

Networks & performance

Some researchers study the impact of structural network positions on various outcome measures. In their study of a large high-tech firm, Podolny and Baron (1997) found that large, sparse networks rich in structural holes had a positive effect on the grade advancement of employees.

Hansen (2002) studied how knowledge is exchanged within large multi-unit organizations. He found that short inter-unit network paths increased knowledge transfer between teams, which led to a decrease in the time needed to complete their projects.

Based on their research on managers of large firms, Gargiulo and Benassi (2000) concluded that a trade-off exists between the safety of cooperation within cohesive networks and the flexibility offered by networks rich in structural holes.
Soda et al. (2004) also studied the effect of past ties on present ties. They studied the cooperation networks of television productions and their impact in terms of the number of viewers for each broadcast. They found that current structural holes, rather than past structural holes, enhance performance. In terms of closure, the past version was more beneficial than present closure.

Uzzi (1999) investigated small firms' network ties and found that firms with embedded relations are more likely to receive lower cost financing. Moreover, social network relations also encourage and motivate a firm, which enhances future performance. Uzzi and Gillespie (2002) found that firms with embedded ties to their bankers benefited more from early-payment trade discounts and evaded late-payment penalties more often than firms without embedded ties.
Hagedoorn and Schakenraad found that firms with such cooperations were more profitable and more innovative (Zollo, Reuer, & Singh, 2003). Based on a sample of 145 biotech alliances, they found that partner-specific experience (the number of prior agreements with a partner) had an effect on alliance performance (measured with items 3 in their survey).
Rowley et al. (2000) used data on strategic alliances in the semiconductor and steel industry. They found that both relational and structural embeddings influence firm performance, but the two effects depend on one another and on the industry.

6.6 THE SPATIAL DIMENSION OF NETWORKS

Inter-firm network studies report on the development of these networks and their consequences. The intention of these studies is not to investigate knowledge spillovers. However, many network studies—for pragmatic reasons or due to the implicit advantages of firm clustering—investigate networks that are bounded in space. In a spatially bounded area, data collection is often easier. Moreover, research is often conducted in one sector that is often situated in a clustered manner.

A good example of a study in one geographic area that was not launched with the goal of investigating the spatial side is Uzzi's (1996) research on embeddedness. Uzzi investigated the volume of exchanges between contractors and manufacturers in New York apparel firms and found that firms organized in networks have greater chances of survival than other firms. However, the positive effect reverses when it reaches a certain threshold.

Other studies analyse networks among firms in which knowledge and information is exchanged. Ingram and Roberts (2001), for example, discovered that friendships among hotel managers positively influence hotel performance.

Zaheer and Bell (2005) examined the network of Canadian "mutual fund" companies. In focusing on relationships between board members with co-memberships in national organizations, as well as those participating inter-firm ownership and "fund management "relationships, they found that networks enhanced firm performance. More specifically, innovative firms that bridge structural holes in their network benefit even more.

Porac et al. (1995) investigated the network of competitors in the Scottish knitwear industry. Based on interviews and a questionnaire, they described how competitors monitor one another's actions and consider them when making their own decisions. Peck (2005) agreed that economic actors are not disconnected, although, in his view, the spatial context for markets is also important. All of these studies point to the conclusion that the spatial dimension of networks is indeed important

Chapter 7: Networks and Knowledge Spillovers

An increasing number of studies have adopted network theory and methods, as outlined in the last chapter, to research the knowledge spillover mechanism behind spatial clusters (Peck, 2005). Researchers apply network methods in several ways by using several types of data, namely:

- Patent citations
- Survey data and interviews
- Strategic alliance data
- Labour mobility data
- Co-patents

7.1 NETWORKS AND CLUSTERS: PATENT CITATIONS

Patent databases provide more information than the number of patents. The individual patent documents, for example, include citations to other patents. These citations can reflect knowledge spillovers between firms because they reflect interactions between firms. In their frequently cited study, Jaffe et al. (1993), for example, compared the geographic location of patent citations with the location of cited patents. They found that there is a clear local dimension in these citations, suggesting localized knowledge spillovers.

Huang et al. (2003) described the development of patent citations in the nano-technology field over time. They gauged development between countries, institutions (firms), and technology fields using network-mapping techniques.

Paci and Usai (2009) also investigated patent citations between European regions. Their main finding was that geographic distance and citation are inversely related. They also showed that intra-regional knowledge flows are highest in the Netherlands, but decrease over time. On the other hand, the internationalization of Dutch patent citations is on the rise, along with the increasingly important role of multinational firms.

It is not surprising that researchers who investigate patents are often cautious about drawing conclusions, as validity issues arise when patents are used as sources of information. Patents are utilized mostly to protect knowledge instead of sharing it.

However, there are all kinds of strategic reasons to apply for a patent. In some cases, patents are used as bargaining capital for a joint venture.

The most important issue is to what extent patent citations (such as in the study by Jaffe et al. (1993)) reflect interactions among firms and, thus, the flow of knowledge. According to Giuri and Mariani (2006), citations to other patents are often added by the patent examiner. In that case, a citation does not reflect a relation at al. Lerner (1994, p. 321-322) noted that patent citations are “the legal equivalent of property boundary markers, showing where the claim touches upon pre-existing ones. Applicants have a duty of disclosure to reveal related patents”. As with scientific articles, the citations in patent documents refer to other patents that comprise relevant background material due to their related content. A citation does not necessarily reflect close cooperation between firms. Accordingly, the spatial dimension of these citations does not necessarily ensure that knowledge spills over locally. (See Breschi et al. (2005) for an extensive and critical review of knowledge spillovers and patent data).

Co-patenting is a more direct type of cooperation between firms that can be derived from a patent file. In the case of a co-patent, two or more firms jointly apply for the patent. Therefore, interaction between these firms is much more likely than for a citation.

7.2 NETWORKS AND CLUSTERS: SURVEYS AND INTERVIEWS

A limited, but increasing, number of studies use primary data based on interviews or surveys to investigate knowledge spillovers within localized inter-firm networks.

Dahl and Pedersen (2004), for example, investigated knowledge flows through informal contacts within a formal cooperative network of wireless communication firms in Denmark. Their results showed that localized flows of knowledge do take place, but their effect on firm performance was not investigated. The generalizability of these results is limited, however, because the surveys were conducted only within one cooperative organization inside this single cluster.

Knoben (2008) adopted a slightly broader perspective and analyzed localized exchanges between firms by employing a survey about inter-organizational linkages among automation service firms. His results confirm the importance of the localization of similar firms. He also found that localization and localized linkages are weakly linked.

Giuliani and Bell (2005a) collected network data at the firm level in three wine-clusters by conducting interviews. They obtained data on advice, technical support, and business interactions. Their results illustrated the structure of knowledge networks within the clusters and how those clusters were linked to external knowledge.
In an analysis based on the same data, Giuliani (2007) found that firms with relatively high technological knowledge were more likely to exchange innovation-related knowledge with other firms in the cluster than with firms with less developed technological capabilities.

Most studies in this field of research investigate only a small number of clusters. Fritsch and Kauffeld-Monz (2009) investigated knowledge exchange on a larger scale. They investigated 16 regional innovation networks in Germany and found that membership in these networks was positively related to inter-organizational knowledge exchange. However, they only incorporated relatively simple network measures and did not link the exchange of knowledge to a performance measure.

Linking surveyed networks with outcome measures

McEvily and Zaheer (1999) did examine the link between knowledge spillovers and outcome measures. Specifically, they investigated spatial clusters in the Midwest region of the United States by interviewing entrepreneurs about their ego-networks. They found that bridging (non-redundant) ties positively influence competitive capabilities.
Bell (2005) also investigated the link between knowledge spillovers and innovation as outcome variables and found that firms located in the main Canadian cluster of mutual fund companies were more innovative. The Canadian network's centrality within the managerial sector also led to increased innovativeness.

Boschma and Weterings (2005) investigated the relationships of Dutch software firms by using a survey. Although they found that firms in specialized regions were more innovative than other firms, they did not find any effect from having regular contact with customers or other software firms (measured with two dummies). Boschma and Weterings recognized that they used a rather crude measure of network contacts, and argued that more in-depth research is needed.
Boschma and Ter Wal (2007) researched the footwear industry in the Barletta footwear district of Italy. They interviewed 33 firms in this district and investigated

different types of knowledge networks using a roster-recall method. Their results revealed that only a limited number of firms were part of the local knowledge network. Moreover, firms that have both a central position in a local network and extra-local linkages at their disposal were more innovative.

Mancinelli and Mazzanti (2009) conducted surveys based on firms' networking activities, as well as their sector and geographic location in a province of the Emilia-Romagna Region. They concluded that regional innovation dynamics result in local spillovers and drive regional networking.

7.3 NETWORKS AND CLUSTERS: STRATEGIC ALLIANCES

Other researchers used data on strategic alliances and formal cooperation as indicators of knowledge exchange. One example is the research conducted by Owen-Smith and Powell (2004). Using data on contractual relationships among biotech firms, they concluded that centrality in the networks of R&D cooperations has a positive effect on patenting volume. They also demonstrated the importance of geographic proximity.

Salman and Saives (2005) investigated strategic partnerships in the Quebec biotech cluster. They studied the effect of network position on innovation output and access to knowledge. Based on their results, they concluded that network centrality enhances innovation and creates knowledge advantages; indirect ties connect firms to a larger dynamic community. Although they investigated firms in a biotech cluster, they did not study the geographic dimension of the ties they investigated.

Appold (1995) found support for the positive effect of collaborative production within the metalworking sector, but he did not find a positive effect pertaining to a firm's location within an agglomeration.

7.4 NETWORKS AND CLUSTERS: LABOUR MOBILITY

Casper (2007) showed that labour mobility can create cooperative links between firms. He investigated the career paths of managers in San Diego biotech firms and described how labour mobility creates a network of linked firms in the region that function as a network backbone anchoring regional growth.

Wenting (2008) took a similar approach and investigated the fashion industry network. He found a similar pattern of parent-spin-off relations. Moreover, Wenting found that spin-offs were often located near their parent firms, driving the spatial concentration of these firms.

7.5 NETWORKS AND CLUSTERS: CO-PATENTING

According to Giuro and Mariani (2006), co-application of patents is the only real type of cooperation provided by the patent document discussed above. However, the documents do not provide details about the organisation a person belongs to (Giuri & Mariani, 2006).

Balconi et al. (2004) performed a descriptive analysis of Italian co-patenting data. Their results showed that networks of inventors are highly fragmented, except in technology fields that emphasize scientific knowledge, such as electronics and chemistry.

In his study about the spatial distribution of co-patenting in Sweden, Wilhelmsson (2009) showed that cooperative patenting is not very common. Co-patenting occurred more frequently in densely populated areas with diversified industries and partners who were located further away. However, cooperation across country borders was rare, although it increases every year.

Ejermo and Karlsson (2006) took a different approach and focused on inter-regional co-patenting networks as sources of knowledge exchange across Swedish regions. As in earlier studies, they found that corporations are dependent on travel distance.

Maggioni and Uberti (2008) also investigated knowledge flows across European regions. Based on an analysis of hyperlinks, co-patent applications, Erasmus student mobility, and research collaborations, they concluded that inter-regional relations generate knowledge. However, the researchers did not use firm-level relationships, so the direct implications for firms were not clear.

Fleming and Frenken (2007) described the development of co-inventor networks in the Silicon Valley and Boston based on EPO and USPTO patents. They observed increased connectedness among those inventors.

In a similar study, Ter Wal (2008) described the development of the high-tech cluster of Sophia-Antipolis. He found that the network was fragmented and that connectivity declined due to new firms entering the region.

Porter et al. (2005) found that the co-patenting network in their study had a tight clustered topology connected by a few central actors.

Cantner and Graf (2006) performed a case study of co-patentees in the Jena region of Germany and investigated the dynamics of the network in different technology fields. They found that personal relationships that originated from previous jobs are one of the main sources of new cooperations. Existing cooperations were not dependent on previous cooperations and, thus, not persistent.

Giuri and Mariani (2006) discovered that the number of co-inventors is higher than reported by co-applications in the documents because during interviews, inventors reported that other co-applicants of “their” patent were from other organizations.
Moreover, Giuri and Mariani (2006) also found that collaboration with geographically close individuals in other organizations is the least important form of collaboration, and that cooperation with geographically close individuals from the same organization was the most important type of cooperation.
Hagedoorn et al. (2003) found that R&D alliances and co-patenting are, against their expectations, not related. Hagedoorn (2003) concluded that although the number of joint patents has increased, firms prefer to have patents in their own possession and, if possible, to split a discovery and patent the parts separately. In addition, he found that the amount of co-patenting differs across technologies.

These studies describe the patterns in space, across technology fields, and over time, but do not assess the outcome implications for a firm. One reason for this is that most studies focus on inventors, not firms (Ter Wal & Boschma, 2009). Because of this focus on inventors, the related firms remain out of sight. Another issue is that co-inventors are often employees at one firm. As a result, cooperative relations are not a good indicator of knowledge spillovers between firms, but, rather, a reflection of cooperation within firms. Therefore, much is still unclear about the extent to which co-patenting patterns are a valid indicator of local interaction. Moreover, it is also unclear whether co-patenting behaviour influences firm performance.

7.6 DESIGN ISSUES

As shown earlier, many studies that attempt to provide clarity about local knowledge spillovers are anecdotal in nature (Malmberg, 1996). In addition, most studies focus on success stories (Malmberg, 1996; Wiig & Wood, 1995). Often, just one region or a small number of regions are investigated or compared. Martin and Sunley (2003) pointed out that only very few studies compare similar firms inside and outside clusters.

Another issue is that although researchers frequently reference the study of informal networks, their operational measurements are often based on geographic concentrations of R&D activity (Breschi & Lissoni, 2001a). Most researchers that did investigate networks only focused on small-scale networks within one sector or region and provided only partial information about networks based on samples of firms, instead of focusing on the entire population. Therefore, the links between local networks, localized knowledge exchange, firm performance, and economic growth remains somewhat unclear. As a result, much is still unknown about the micro-mechanism driving knowledge spillovers.

Despite the popularity of network concepts, scientists rarely measure the spatial dimension of networks among firms in an empiric manner. Although the number of studies outlined in this chapter seems large, most studies fail to explain the micro-mechanism behind spatial-bounded knowledge spillovers.

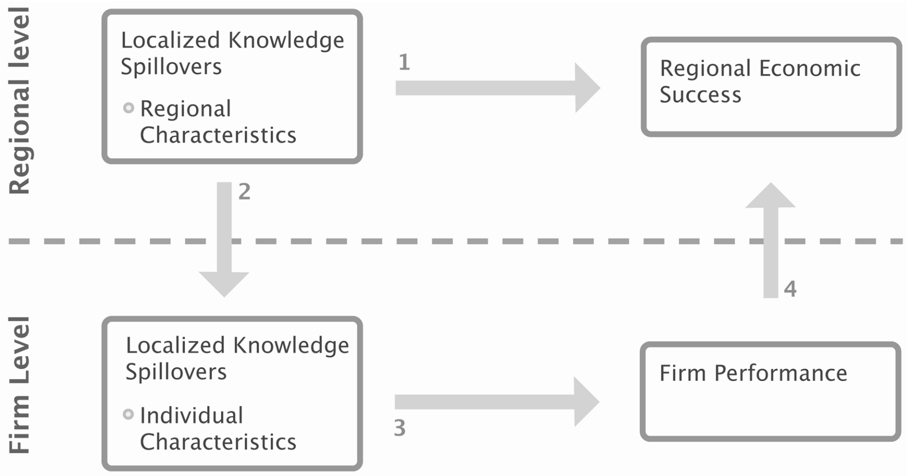
This study aimed to investigate this link by comparing regional networks on a larger scale than previous studies. Moreover, this study aims to link inter-firm networking activity to performance.

7.7 HYPOTHESES

To formalize previous notions about the relationship between regional inter-firm interactions and firm performance, I utilized five hypotheses. Because the link between firm performance and regional success is a typical micro-macro problem, the Coleman-boat is used to illustrate the hypotheses.

On the macro-level, the link between localized spillovers and regional success can be tested using regional indicators (global indicators), such as the number of associations in a region or population density (see Figure 6).

Figure 6. The Micro-Macro Problem of Knowledge Spillovers



A global indicator of success could be the regional immigration rate, the regional level of unemployment, or the number of start-ups in a region. As outlined above, many studies use regional aggregate characteristics, such as the average regional patent-cooperation or the average regional association behaviour. On the aggregate level, this leads to an increased average firm performance (see arrow 1 in Figure 6). To investigate this link on the micro-level, I moved to individual firm characteristics (following arrow 2 in Figure 6). Individual firm characteristics consequently influenced firm-level outcomes (see arrow 3 in Figure 6).

In this research, I used information about entire networks in multiple regions to investigate localized knowledge exchange on a larger scale. Since informal types of relationships among firms are considered especially important conduits for knowledge spillovers, this research concentrates on informal relations. Based on ideas presented in the previous literature on knowledge spillovers and informal relationships, I formulated the following hypotheses (see Figure 7). The first hypothesis on the regional level is as follows:

Hypothesis 1

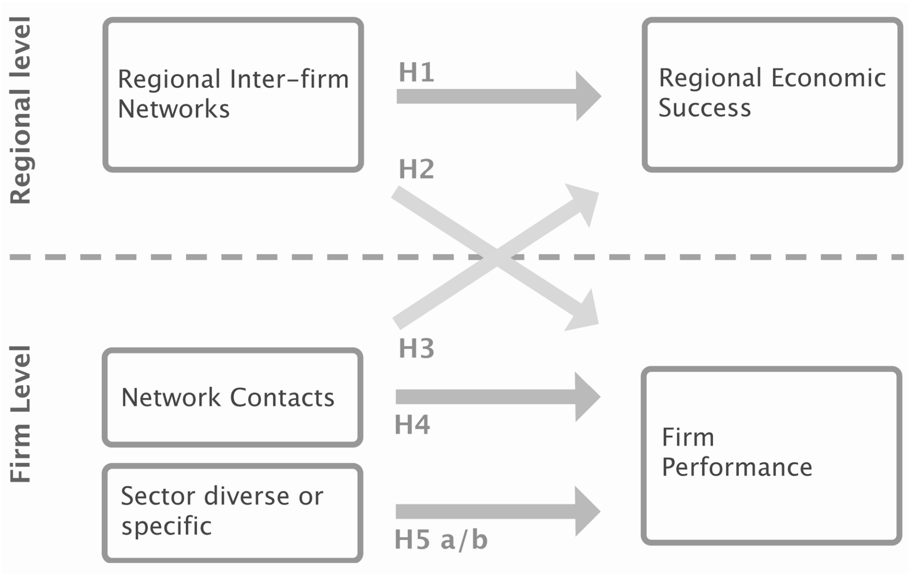
The more network participation there is within a region, the better the performance of that region.

It is also to be expected that there is an individual advantage to regional network participation. Therefore:

Hypothesis 2

The more network participation there is within a region, the better the individual performance of firms within that region.

Figure 7. Graphical Illustration of the Five Hypotheses



On the other hand, moving to the micro-level, individual firm characteristics can also influence average regional success.

Hypothesis 3

The more that individual firms participate in regional networks, the better the performance of a region.

As mentioned earlier, this study focuses on the micro-level. The firm-level hypothesis reads as follows:

Hypothesis 4
The more that individual firms participate in regional networks, the better their individual performance.

The composition of network contacts should have an impact on firm performance via knowledge spillovers. In the wake of the Marshall and Jacobs controversy, the question becomes whether these knowledge spillovers occur across similar or dissimilar types of firms. I hypothesize that:

Hypothesis 5a
The more that the network contacts of firms are sector-diverse (i.e. links to firms outside their own sector), the better the individual performance of firms (Jacobs).

Hypothesis 5b
The more that the network contacts of firms are sector-specific (i.e. links to firms within their own sector), the better the individual performance of firms (Marshall).

The way these hypotheses will be tested is shown in the following chapter on the design of this study.

Chapter 8: Research Design and Data Collection [4]

8.1 RESEARCH STRATEGY

While outlining previous studies about knowledge spillovers, it became obvious that much is still unclear about whether and how firms benefit from localized knowledge spillovers. Most studies investigated just a small number of regions and they often only focused on successful cases. Moreover, the number of studies that focused on networks is limited. What is especially lacking is research on inter-firm networks on a larger scale that also compares clustered and non-clustered firms.

The aim of this research is to test whether localized knowledge spillovers can be explained by inter-firm interactions that are conducive to firm performance. The data will be compiled based on a considerable number of firms and regions. These data will enable a multilevel regression analysis to test if regional networks impact firm performance.

In order to investigate the relationship between spatial agglomeration, social networks, and firm performance, I used data from four different sources.

Table 1. The Four Sources of Data

- Firm-level information
- Regional statistical information
- Network information based on co-patents
- Network information based on the memberships of business associations

First, I obtained firm information at the establishment level (i.e., employment growth) of high-tech Dutch firms across all 40 Dutch regions. Second, the dataset was enriched with regional economic statistical information. Third, I investigated knowledge spillovers via interactions using patent data in all Dutch regions. The

[4] Parts of this chapter are published as (Boshuizen, Geurts, & Van der Veen, 2009)

fourth element of the dataset consists of network data constructed from the membership registrations of all business associations in 11 selected regions.
This chapter will discuss how these data are collected. One of the innovative aspects of this research is the combination of different sources of data, and I will also explain how the different parts of data are merged into one dataset.

8.2 FIRM-LEVEL DATA: HIGH-TECH FIRMS

For this study, I decided to focus on high-tech firms as cases at the lowest level of analysis. The reasoning is that if the knowledge spillover mechanism works, it should work especially well for high-tech firms. This assumption is confirmed by Henderson (2003), who proved that the localization of high-tech industries indeed has a positive impact on the productivity of firms. There are two main reasons that justify this choice.
First, due to the complexity of their products, the advantages of localization economies via knowledge spillovers are most likely to occur in high-tech industries. High-tech firms are more often related to university-related knowledge, more often dependent on technical innovations, and less dependent on the availability of raw materials.
The second reason why the knowledge spillover mechanism should work especially well for high-tech firms is that these firms have only limited transportation constraints. They are, for example, less dependent on geographic distance to a harbour or highway than heavy industry firms. Therefore, they are free to choose a location that is beneficial for their firm in terms of the external knowledge that can be acquired there.

Selection of sectors

I selected all firms that are active in the sectors of “Scientific research and development” and “Manufacture of instruments and appliances for measuring and testing”[5]. The data were obtained from the register of the Dutch Chamber of Commerce[6].

[5] The criterion was that at least one of the main official activities was in the selected sectors (firms can report up to three main sectors). We used the following Dutch SBI sector codes (with the NACE 2 equivalent):
- SBI 731 (NACE2 m72): Scientific research and development
- SBI 332, 333 (NACE2 c265): Manufacture of instruments and appliances for measuring and testing; Manufacture of instruments and appliances for monitoring of industrial processes.

[6] Dutch firms are obliged to be registered at the Chamber of Commerce. Because we acquired data for all Dutch firms in the selected high-tech sectors, we avoided selection bias. Moreover, it allowed for a check on robustness across regions.

8.3 REGIONAL ECONOMIC DATA

The second part of the dataset consists of regional data at the NUTS-3 level obtained via Statistics Netherlands. These data are used to measure the regional-level characteristics.

Figure 8. The Dutch NUTS-3 Regions

Source: RIVM, 2008; based on CBS data

This study focuses on the 40 Dutch NUTS-3 regions (see Figure 8) because Statistics Netherlands based the division of the region on the scope of economic activities and employment mobility. Because economic activity is centred in the 40 regions, it is likely that local knowledge spillovers occur within these regions rather than between them (Van Stel & Nieuwenhuijsen, 2004). Therefore, these particular regions provide a strong focus for an inter-firm network analysis.

8.4 CO-PATENT NETWORKS

The third element of the dataset consists of co-patenting network characteristics. Network links derived from patent applications are seen as a possible source of knowledge spillovers and as a promising approach to investigating regional networks (Ter Wal & Boschma, 2009). However, as outlined in Section 7.4, much is unclear about the spatial scale of these networks and their implications.

In this study, I investigated a subset of approximately 112 million patents in the EPO dataset containing patents worldwide. The patent-file contains names of the involved "persons". A "person" can be an applicant or an inventor, and can also be an organization name. Because I wanted to obtain information about co-patenting behaviour among Dutch firms, all of the selected patents included at least one Dutch "person" (applicant or inventor). In the patent data, 50% of the applicants' country codes are provided [7]. The EPO organization (2007) suggests imputing these cells with the country of patent application. Therefore, I also added all of the patents applied for at the Netherlands patent office. At the same time, I also restricted the timeframe of the study to patents applied for between January 1990 and December 2007.
I chose this timeframe because not all firms register patents frequently. Moreover, it often takes a long time to prepare a patent application. A patent is not a short-term investment; it is most often used to protect an invention for a longer time. Because of these factors and because other studies found fragmented cooperation networks, as well as to avoid being too strict in the selection of time, it was decided to set the selected timeframe ten years prior to the measurement of performance (1990). The selected subset contained 737,587 patents.

Data issues

In the course of this research, there were some patent data issues that required consideration. The missing country codes discussed above comprise just one example. Another issue was the many misspellings in the data. Moreover, as Fleming and Frenken (2007) point out, the patenting procedure is focused on the administration and protection of patents, including knowledge. Only patents are given a unique code. Applicants and inventors also have codes, but separate applications by one "person" are not always combined because different departments of an organization submit patents, organizations are listed under different names, or their names are misspelled (see Table 2).

[7] "Note: only 50% of country-codes are present. In future versions, we hope to be able to fill the missing codes with the country of publication" (EPO, 2007, p. 39).

Table 2. Different Names and Misspellings in the EPO Database

AKZO Nobel NV	Philips Electronics NV
AKZO NOBLE N.V.	CORNINKLIKE PHILIPS ELECTRONICS M. V.
AKTSO NOBEL' KOATINGS INTERNEHSHNL B.V.	KINONKLIJKE PHILIPS ELECTRONICS N.V.
AKZO NOBLE N.V	PHILPS ELECTRONICS N.V.
AKZO Nobel Research	Koninkijke Phillips Electronics N.V.
Akco Nobel NV	KONINK PHILIPS ELECTONICS N. V.

Based on the raw scores, the firms in the patent database turned out to differ greatly in their patenting behaviour. The largest number of patents of one "person" was Philips, with 29,430 patents. Most of the "persons" (174,802) had just one patent (in most cases, they were employees). Manually reviewing the patent applications revealed that in a majority of cases, one organization was involved in a patent and the other "persons" in the file were natural persons. However, in some cases, more than one organization was involved, and these patents comprise the co-patents needed to study networks. It turned out that most of the patent registrations included one "person" name (144,171). The largest number of "persons" (applicants or inventors) for one patent was 27.

Due to the prevalence of different name spellings and different department names, it was not possible to directly link the patent name with the names in the Chamber of Commerce data. Therefore, a matching algorithm (computer script) was developed, which resembled that of Fleming and Frenken (2007), who mutually matched the inventor names to determine co-inventorship. However, this research differs because it aims to investigate links between *organizations* instead of inventors. Therefore, the algorithm used for this study compares "person" names with firm names in the Chamber of Commerce data file.
To be able to determine which patent-person names in the patent file matched firm names, all unique "person" names were subtracted from the patent data, resulting in a list of 244,146 names.

Matching script

The unique "person" names were entered in the script. First, the script generated a list of firm-pairs ranked in three categories based on their chance of constituting a match. This ranking was based on letter combinations of the applicant names. All applicant and inventor names were compared with the names of organizations in the

Chamber of Commerce data. For example, all names including the word “research” would at least be suggested as a “vague match”. In a similar way, “almost identical” names and names with “significant similarities” were distinguished (see Figure 9). As a second step, the ranked matching results were evaluated manually. In the last stage, after processing the reviewed matches, the script processed a matrix of the total regional affiliation network with the combined registration numbers.

Due to the large number of patents and inventors in the database, I had to focus on the selected high-tech firms. Comparing the names of applicants with all other applicants in the database would be impossible, given the time it would take to compute and review the matches.

The matching procedure resulted in a data-matrix with the “person” names and the Chamber of Commerce registration numbers. The “person” names could be linked to the patent information, enabling the linking of patent information with firm characteristics, such as performance.

Resulting patent data

After the script matched the patent data with the Chamber of Commerce registrations, it turned out that of the 2,491 Dutch high-tech firms, 385 were involved in 137,166 patents. Seventy-one of these high-tech firms registered one patent; Philips was the company that applied for the maximum number of patents (74,284). The distribution is highly skewed. Most firms have less than 10 patents, but the maximum is much higher than the average of 357 patents (see Table 3).

Figure 9. Results Screen of the Matching Script

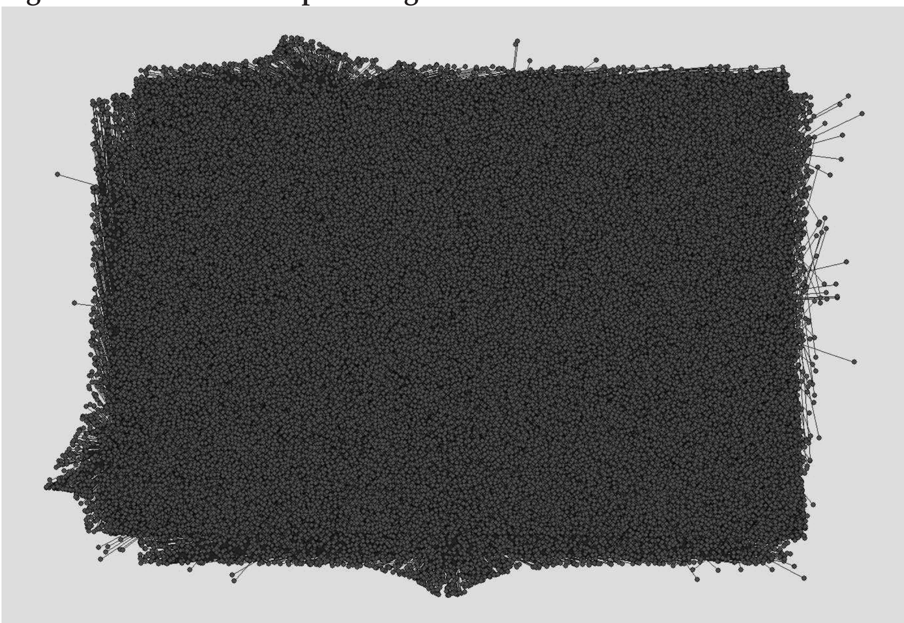
Table 3. The Distribution of Patents per Firm

Percentiles	Number of patents
10	1.00
20	2.00
30	2.00
40	3.00
50	4.00
60	7.00
70	11.00
80	18.80
90	37.40

N=385, mean=356.77, max=74,284

Figure 10 shows the resulting network of firms and their related patents. It is not recognisable, but the patent-network is not connected in one large component; it consists of many separate clusters.

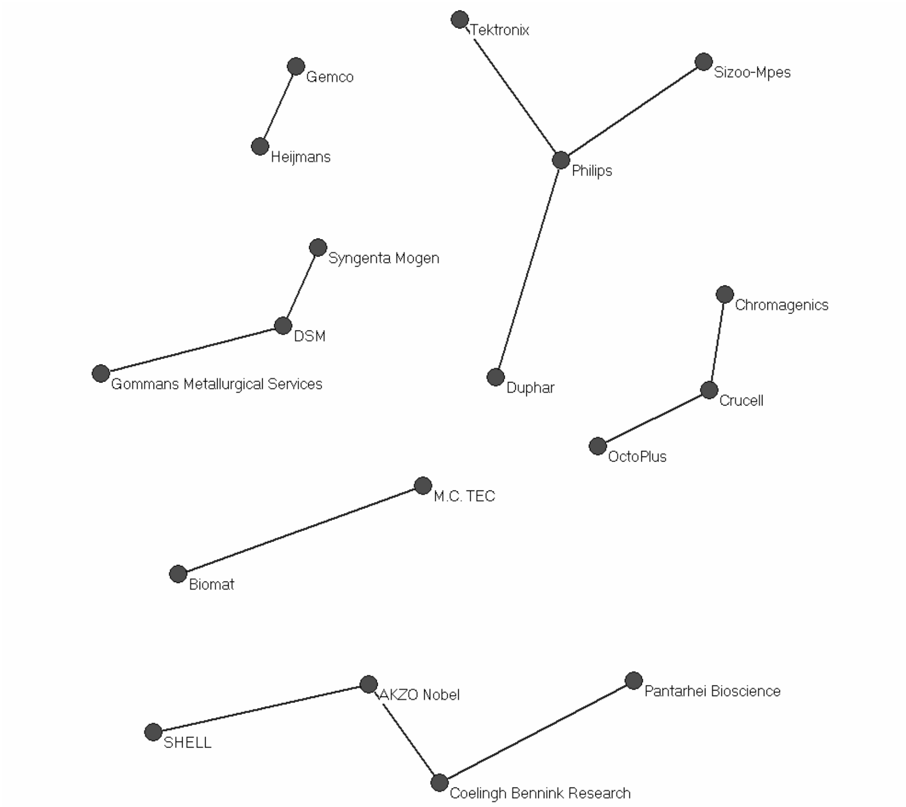
Figure 10. Network-Graph of High-Tech Firms and Patents



From this network, the co-patenting network was derived. This resulted in a sparsely connected network. Of the 385 firms, 17 firms (0.4%) had 83 cooperative patents (see Figure 11).

The resulting co-patenting network shows that even in the high-tech sector, cooperative patenting is not a common practise. There are three notable components to these results. First, there is a component with AKZO Nobel as a key organization linked with Pantharei, Be-best, and Shell. Another component has Philips as the central actor connecting Duphar, Tektronix, and Sizoo. The third component has DSM Research as main organization that is connected with Syngenta and Gonmans. Two smaller components linked the remaining companies.

Figure 11. The Co-Patenting Network



Large firms, in particular, seem to have co-patenting relationships (the correlation between the size and number of patents is .20; see Table 16 in Chapter 9). A majority of the firms in the network are biotech-related. This is consistent with other studies that found more cooperation between biotech firms than other types of high-tech companies (Hagedoorn, Cloodt, & van Kranenburg, 2005). The 18 organizations in the co-patenting network all have an international orientation. Because the number of firms with co-patents is relatively small, shifting the focus of this element of this research to the regional-level, would lead to networks that are barely connected. Therefore, the co-patent network is included in the final analyses on the firm-level.

8.4 BUSINESS ASSOCIATIONS NETWORKS

The last part of the database consists of a more informal type of social network data. In a pilot study of high-tech Dutch entrepreneurs, I used interviews to collect data on networks. Entrepreneurs were reluctant to share a lot of detailed information about their networks because they regarded their network contacts as part of their strategic capital. Almost automatically, they started mentioning membership in business associations as an important means of establishing and maintaining regional network contacts and acquiring access to knowledge. Firms were, for example, members of business associations aimed at stimulating knowledge exchange across sectors, or members of associations for high-tech firms. Others were members of business associations designed to enhance exports. The main goal of those business associations is to stimulate business by exchanging knowledge and experiences. Therefore, the decision was made to investigate these memberships more thoroughly, and to use membership as an indicator of networks for entrepreneurs.

Figure 12. A Business Association Meeting

Business associations regularly organize activities and meetings to foster face-to-face contact and the exchange of knowledge, information, and experiences in order to facilitate business. This can lead directly to new business, or inspire entrepreneurs to develop innovative ideas. In the sectors I investigated, in most cases, the CEO participates in the business association. Because most of the firms are small or medium-sized, their CEOs are involved with the direct leadership and strategic decisions of the firm. Therefore, knowledge and information could easily spillover between the firms and impact performance. The value of membership in associations as an important source of social capital is stressed by many researchers (e.g. Coleman, 1990; Putnam, 1993).

Sampling of regions

Compared to the gathering of standard regional economic data, the collection of membership data turned out to be a time-consuming and difficult job. Therefore, I had to make a selection from the 40 total NUTS-3 regions for the collection of network data. As Rosenthal and Strange (2004) point out, focusing only on urbanized or specialized areas can lead to selection problems that hamper the generalizability of the results. I avoided this by sampling "most different" cases. The stratification criteria I used were: (1) the share of high-tech firms, (2) the availability of a university, (3) geographic location, and (4) urban density. Based on these criteria, I selected a total of 11 regions[8]. In these 11 regions, 563 of the 1,881 high-tech Dutch establishments are present.

Figure 13. Selected NUTS-3 Regions

Source: RIVM, 2008; based on CBS data

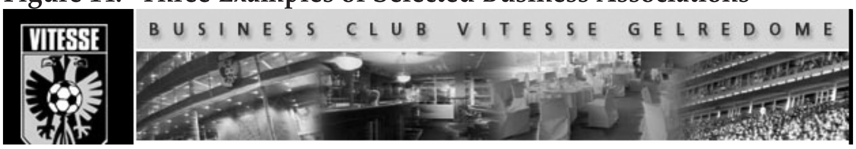
[8] The regions we selected are: North-Drenthe, Southwest-Friesland, Northwest-Overijssel, Twente, Arnhem/Nijmegen, Southwest North-Brabant, Delft-Westland, Leiden-Bollenstreek, Gooi en Vechtstreek, Alkmaar, and Den Helder.

In the 11 regions I selected, all of the business associations had an explicit goal: “stimulating mutual contacts”, “exchanging knowledge”, or “facilitating doing business”, as well as “networking” [9].

Collection of membership data

The membership data were collected in three stages. First, I obtained lists of all the business associations in a region from the local Chamber of Commerce and expanded this list with information from municipalities and regional websites from, for example, development agencies and other business association websites. Second, I excluded interest groups with only a national orientation, and business associations aimed at one profession only, such as bakers and dentists, or with a focus on a non-high-tech sector, such as retail stores or restaurants. Service clubs were also excluded because these associations are mainly aimed at personal success, retaining their club members even if they change jobs; this makes it difficult to relate membership to the performance of any one firm.

Figure 14. Three Examples of Selected Business Associations



a. Soccer-related

b. Export-oriented

c. Breakfast business meetings

[9] One remark needs to be made. All co-members of a club are directly linked in the network. Our network data do not contain information about actual social interactions, but only information about potential contacts. However, that is what social capital is all about: a resource that can be accessed via contacts.

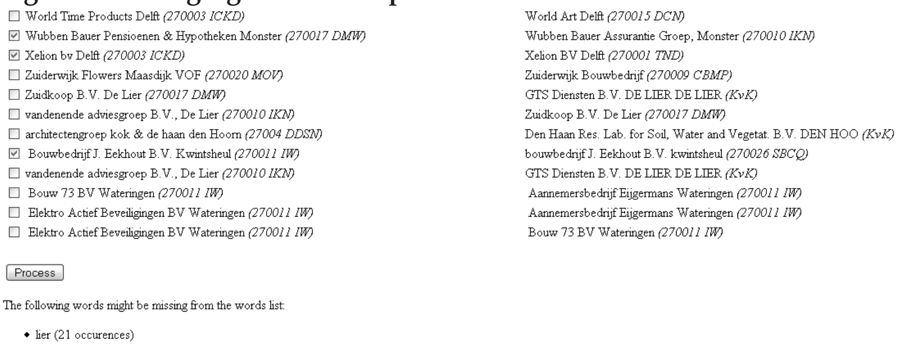
It took almost half a fulltime year to compute the statistics for the business associations.

The regional networks I focused on clearly had a regional focus that matched the NUTS-3 regions quite well. Only a few members of these business associations crossed a regional border. This fact shows that firms are clearly focused on contacts within the region. The 325 business associations I selected turned out to have 25,880 members. This means that about 12% of all firms in the sampled regions are members of an association. To be able to link these numbers with performance, I used the same computer-script employed in the case of the co-patent network.

Merging the data

As with the patent data, the lack of availability of Chamber of Commerce registration numbers prevented the direct coupling of membership data with firm data. Because firms did not always use their official names for membership, a simple match based on their names was also impossible. Therefore, the computer algorithm described earlier was used again to match membership data with Chamber of Commerce data. The script in this case not only compared the names of member-firms with the Chamber of Commerce registration, but also with the names of other members in the data. As a result, both high-tech and other member-firms are represented in the resulting regional networks.

Figure 15. Merging Membership Data



Regional networks in 11 regions

The regions were selected to allow for diversity. The descriptives in Table 4 indicate that the stratification criteria worked and that the selected regions differ in size, number of associations, number of memberships, and the involvement of high-tech firms. One initial striking aspect of the research is the percentage of participating firms. Across the 11 regions, I found that only 17% of all high-tech firms participated in a regional business association. This means that a minority of these firms participate in these associations.

Table 4. Average Statistics of the 11 Networks

	Mean	Minimum	Maximum
Nr. of establishments[a]	19,454	6,860	40,070
Nr of associations	29.45	14	66
Nr of firms in network	2352.9	967	5208
Nr.of memberships	1.13	1.03	1.29
Members per establishment	0.119	0.083	0.16
Nr associations per establishment	0.0015	0.0011	0.0022
NR high-tech firms in region	67.36	8	157
Number of high- tech firms in the network	11.64	1	33
Percentage high-tech firms in network	0.17	0.07	0.29

[a]: Source: statistics Netherlands (CBS) 2007.

The 11 investigated regional networks are shown below. The blue dots are clubs, the red dots are non-technical firms, and the green dots are high-tech firms. The network graphs provide some insight on the number of firms and the links between them, but the linkages are difficult to distinguish, especially in the larger networks. The tables with regional characteristics give information that is more objectively interpretable.

Twente and Arnhem/Nijmegen are regions in the Eastern part of the Netherlands. Both regions have a university. The percentage of high-tech firms with memberships is largest in Twente (Table 5). In Arnhem/Nijmegen, this percentage is much lower (9%). Figure 16 shows the network that reflects this pattern. The general network graphs show that participation in business associations in the two regions is similar. The average number of memberships in Twente is the highest of all the investigated regions (1.29). This average is larger than that of Arnhem/Nijmegen, where the number of memberships is 1.2, which is also higher than the Dutch average (1.13).

Figure 17 illustrates the networks of the Delft and Leiden areas. The numbers in Table 6 show that participation in associations (members per establishment) in the Delft region is below average (0.083 compared to 0.119 on average). In Leiden, this number is above average (0.134). Firms in both regions have, on average, fewer memberships than other regions (Delft, 1.1 and Leiden, 1.11, compared to 1.13 on average). This is reflected in the relatively few number of bridging firms in Figure 17.

North-Drenthe and Southwest-Friesland are relatively small peripheral regions without a university. Participation in business associations in both regions is below the average percentage (see Table 7). The percentage of high-tech firms in North-Drenthe (19%) is higher than the average (17%), whereas in Southwest-Friesland, this percentage is below average (13%). The high-tech networks in Figure 18 are sparsely connected.

Eindhoven is an important industrial region in the Netherlands. This region also has one of the technical universities. Het Gooi is a smaller region with an important media cluster. Both regions are located in the economic centre of the Netherlands. In het Gooi, the percentage of high-tech firms in the regional network is 7% below the average (which is 17%). This number is higher in the Eindhoven region at 16% (see Table 8). Figure 19 shows the two network graphs of these regions.

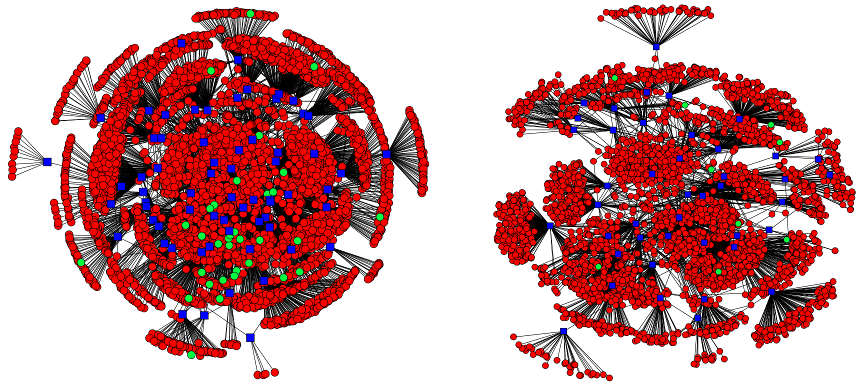
Figure 20 shows the networks of the Den Helder and Alkmaar regions. These regions are both located in the northwest part of the country. The percentage of high-tech firms in the Den Helder region is 27% higher than in Alkmaar (16%). Both networks are more sparsely connected than average because the number of memberships is lower than the average (see Table 9).

Northwest-Overijssel (Figure 21) is the last region. Participation in business associations is below average there (see Table 10). The high-tech firms are members of one association that is not (directly or indirectly) connected to the largest network component in the region.

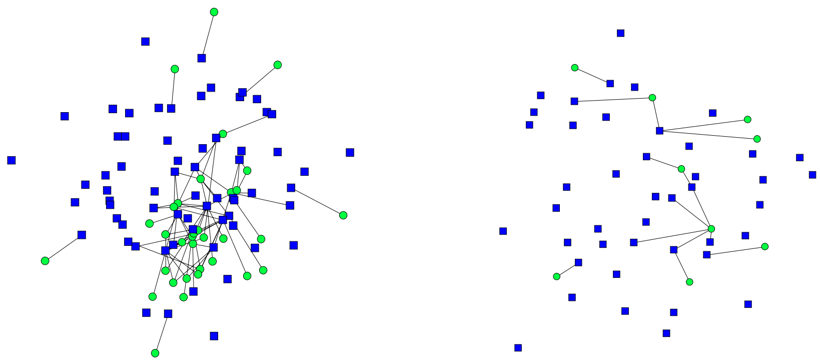
The differences between the networks in the selected regions indicate heterogeneity in the selected regions. This increases the likelihood of finding a regional effect in the analytical part of the study.

Figure 16. Networks of the Twente and Arnhem/Nijmegen Regions

Twente Arnhem/Nijmegen



General regional networks showing all business associations and all establishments



Same networks as above, but showing only high-tech establishments

(Red circles: firms; blue squares: clubs; green circles: high-tech firms)

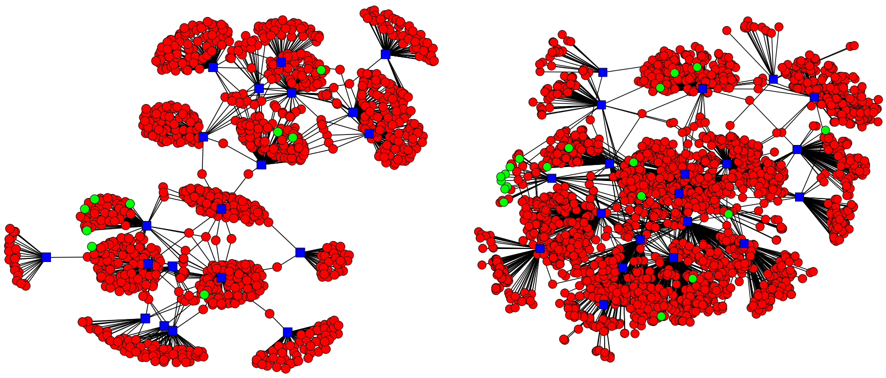
Table 5. Descriptives of Twente and Arnhem/Nijmegen.

Region	Twente	Arnhem / Nijmegen
NR of establishments[a]	29960	31445
Nr. of clubs	66	43
Nr of firms in network	4560	3735
Members per establishment	0.152	0.119
Clubs per establishment	0.0022	0.0014
Average nr of memberships	1.29	1.2
NR high-tech firms in region	113	104
Number of high- tech firms in the network	33	9
Percentage high-tech firms in network	29%	9%

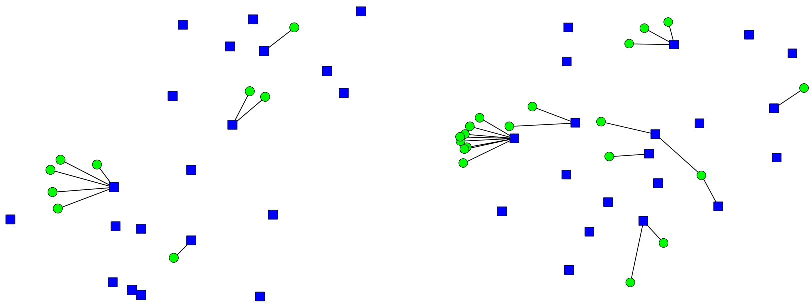
[a]: Source: statistics Netherlands (CBS) 2007.

Figure 17. Networks of the Delft and Leiden Regions

Delft | Leiden



General regional networks showing all business associations and all establishments



Same networks as above, but showing only high-tech establishments

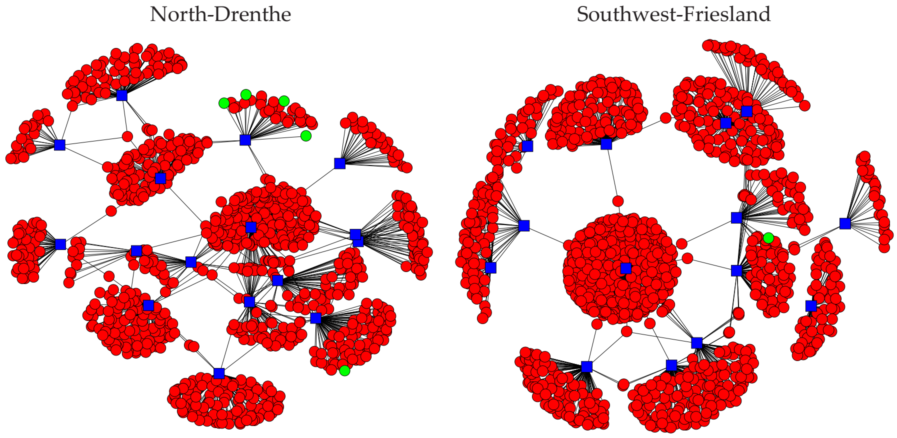
(Red circles: firms; blue squares: clubs; green circles: high-tech firms)

Table 6. Descriptives of Delft and Leiden.

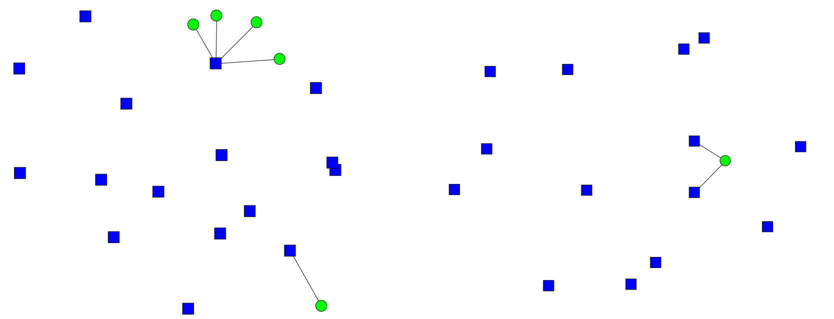
Region	Delft	Leiden
NR of establishments[a]	12290	18530
Nr. of clubs	20	20
Nr of firms in network	1025	2484
Members per establishment	0.083	0.134
Clubs per establishment	0.002	0.001
Average nr of memberships	1.1	1.11
NR high-tech firms in region	72	107
Number of high- tech firms in the network	9	19
Percentage high-tech firms in network	13%	17%

[a]: Source: statistics Netherlands (CBS) 2007.

Figure 18. Networks North-Drenthe and Southwest-Friesland



General regional networks showing all business associations and all establishments



Same networks as above, but showing only high-tech establishments

(Red circles: firms; blue squares: clubs; green circles: high-tech firms)

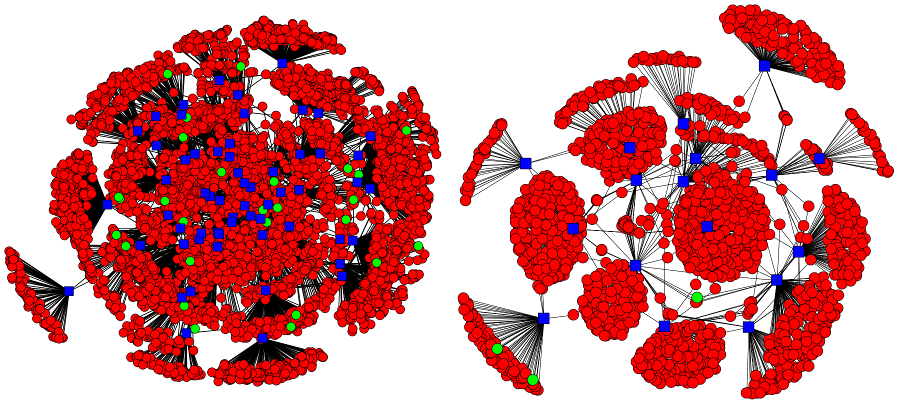
Table 7. Descriptives of North-Drenthe and Southwest-Friesland

Region	North-Drente	SW-Friesland
NR of establishments[a]	9090	6860
Nr. of clubs	16	14
Nr of firms in network	967	1094
Members per establishment	0.106	0.16
Clubs per establishment	0.002	0.002
Average nr of memberships	1.09	1.03
NR high-tech firms in region	27	8
Number of high- tech firms in the network	5	1
Percentage high-tech firms in network	19%	13%

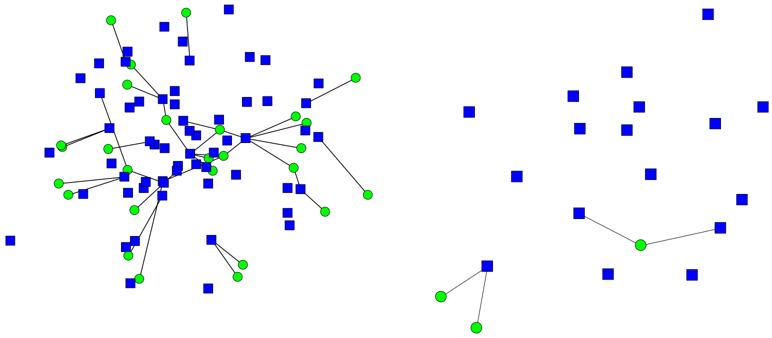
[a]: Source: statistics Netherlands (CBS) 2007.

Figure 19. Networks of Eindhoven and Het Gooi Regions

Eindhoven | Het Gooi



General regional networks showing all business associations and all establishments



Same networks as above, but showing only high-tech establishments

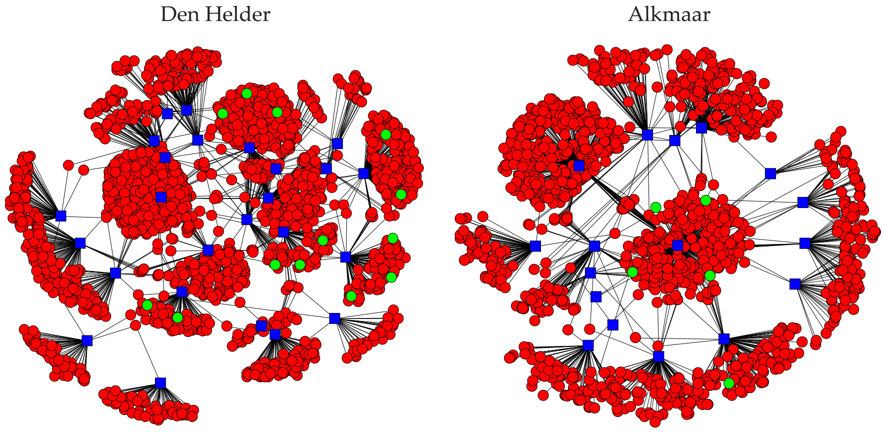
(Red circles: firms; blue squares: clubs; green circles: high-tech firms)

Table 8. Descriptives for Eindhoven and Het Gooi

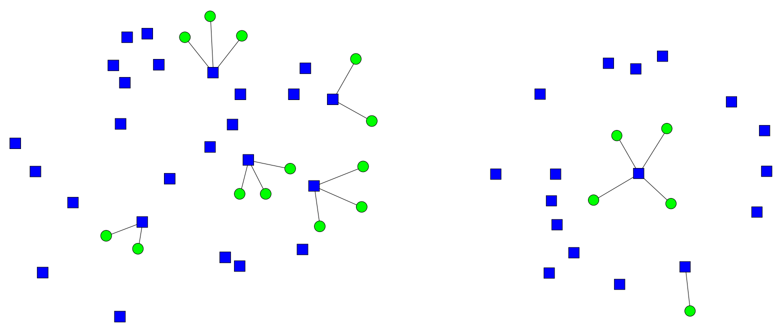
Region	Eindhoven	Het Gooi
NR of establishments[a]	40070	16005
Nr. of clubs	60	17
Nr of firms in network	5208	1587
Members per establishment	0.13	0.099
Clubs per establishment	0.002	0.001
Average nr of memberships	1.15	1.09
NR high-tech firms in region	157	43
Number of high- tech firms in the network	27	3
Percentage high-tech firms in network	16%	7%

[a]: Source: statistics Netherlands (CBS) 2007.

Figure 20. Networks of Den Helder and Alkmaar regions



General regional networks showing all business associations and all establishments



Same networks as above, but showing only high-tech establishments

(Red circles: firms; blue squares: clubs; green circles: high-tech firms)

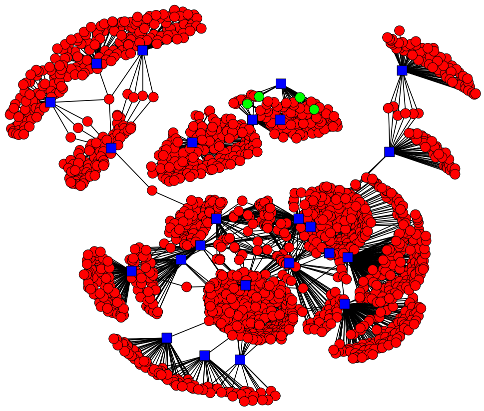
Table 9. Descriptives of Den Helder and Alkmaar.

Region	Den Helder	Alkmaar
NR of establishments[a]	20165	11395
Nr. of clubs	25	17
Nr of firms in network	1977	1493
Members per establishment	0.098	0.131
Clubs per establishment	0.0012	0.0015
Average nr of memberships	1.12	1.09
NR high-tech firms in region	48	32
Number of high- tech firms in the network	13	5
Percentage high-tech firms in network	27%	16%

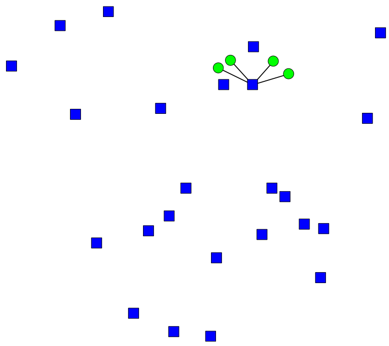
[a]: Source: statistics Netherlands (CBS) 2007.

Figure 21. Network of Northwest-Overijssel

Northwest-Overijssel



General regional networks showing all business associations and all establishments



Same networks as above, but showing only high-tech establishments

(Red circles: firms; blue squares: clubs; green circles: high-tech firms)

Table 10. Descriptives of Northwest-Overijssel

Region	Northwest-Overijssel
NR of establishments[a]	18190
Nr. of clubs	24
Nr of firms in network	1752
Members per establishment	0.0963
Clubs per establishment	0.0013
Average nr of memberships	1.12
NR high-tech firms in region	30
Number of high- tech firms in the network	4
Percentage high-tech firms in network	13%

[a]: Source: statistics Netherlands (CBS) 2007.

Chapter 9: Model and Operational Measures [10]

9.1 MODEL AND RESEARCH METHODOLOGY

This chapter presents the research model and operational measures that were used to answer the research hypotheses from Chapter 7, based on the data presented in Chapter 8. To test the relationship between entrepreneurial networks, spillover mechanisms, and firm performance, as formalized in the model, I used a multilevel regression analysis.

9.2 MULTILEVEL ANALYSIS

Multilevel analysis is a method that should be used to analyse data with a nested or hierarchical structure (Hox, 1995). Due to the effect of the higher levels on the lower levels, nested data do not fulfil the assumption of independent observations. As a result, a normal OLS-regression is not suitable. The problem with performing an OLS-regression on nested data is that standard errors are underestimated, which leads to the overestimation of significance levels (Hox, 1995).
Multilevel analysis (or hierarchical linear models) can be used to account for unexplained variability at the different levels of nesting (Snijders & Bosker, 1999). Therefore, it generates robust standard errors. Multilevel analysis separates the variances at different measurement levels. I considered two levels: Level 1 contains individual firms (subscript: i) and Level 2 reflects the regional level (subscript: j).

Multilevel analysis is often illustrated through research on child performance in classes and schools. In the regional economic setting, it can be used to separate the firm level and the regional level (see, e.g., Boschma & Weterings, 2005).

The random intercept model is a simple type of hierarchical linear model containing the effects of individual-level variables. The difference, however, is that for every region, the deviance from the average intercept is estimated. As an example, the model with one independent variable is shown below.

$$Y_{ij} = \beta_{0j} + \beta_1 x_{ij} + R_{ij}$$

[10]: Parts of this chapter are published as (Boshuizen et al., 2009)

The intercept β_{0j} can be divided into an average intercept, "γ_{00}", and a random part on the regional level, "U_{0j}" (Level 2 residual).

$\beta_1 x_{ij}$ is the regression coefficient at the individual (firm) level, and R_{ij} is the Level 1 residual.

Intraclass correlation= $\dfrac{\tau_m^2}{\tau_m^2 + \delta_m^2}$

$\delta_m^2 =$ Individual-level variance of model m

$\tau_m^2 =$ Intercept variance of model m

9.3 RESEARCH MODEL

The model specification was based on the research conducted by Hoogstra and Van Dijk (2004 p. 184), and extended into a multilevel framework (see Figure 22).

Figure 22. Multilevel Model

$FEMPGR_{ij} = CONSTANT + \beta\ FIRM_{ij} + \gamma\ CONC_j + \mu\ NETW_{ij} + U_j + R_{ij}$

(U_j = Random effect at the regional level; R_{ij} = Random effect at the individual level; (i = firm level; j = regional level)

In Figure 22, the dependent variable FEMPGR stands for "firm employment growth". FIRM consists of a set of firm-level controls. CONC contains a variable concerning the regional-level concentration of high-tech firms. NETW contains the set of network-related knowledge spillover measures. How these concepts are measured is outlined in the next section.

9.4 FIRM PERFORMANCE AND CONTROLS

Since my goal was to analyze the performance differences caused by regional knowledge spillovers via network contacts, I used a firm-level performance measure (FEMPGR) (Hoogstra & Van Dijk, 2004; Van Oort, 2007).

Firm employment growth

According to Audretsch and Feldman (2004), the most prevalent measure of firm performance has traditionally been employment growth. The employment indicators I used are approved by chartered accountants, and thus constitute a reliable source.

To avoid the influence of incidental performance fluctuations, I chose a timeframe of five years to measure firm performance. This means I started with firms with a valid performance score in both 2001 and 2005. I also included information about full-time employment levels in 2001, 2005, and 2007 in the database. Because the numbers for 2001 and 2005 were more reliable, I focused on those years. For firms missing a value for 2001, I used the 2005 to 2007 timeframe instead, and added a dummy. For firms with a missing value for 2005, I used the 2001 to 2007 timeframe—also with a dummy added. In both cases, the timeframe was standardized to obtain growth rates for a five-year period (see Table 11).

Alternative performance measures

Several alternative performance indicators were reviewed, such as the financial position of firms. Solvability turned out to be the financial ratio with instable outcomes, which is prone to missing values, tax policies, and bank policies. Moreover, solvency turned out to be strongly related to the age categories of firms. Therefore, using solvency was not an option (this is consistent with the findings of Gulati and Gargiulo (1999)). Using turnover as a performance measure would have been an alternative if these data had been available. Another performance measure that could have been used is the number of patents over time. However, then smaller firms would be underrepresented.

Firm level controls

The first set of explanatory variables in the model (FIRM) consists of a set of firm-level controls, such as firm size, firm age, firm sector, age x size, and the number of patents for the firm.

Table 11 shows the variable names, measurements, means, and standard deviations of firm-level employment growth and controls.

9.5 Regional concentration

The second element in the explanatory part of the model (CONC) contains a relative regional concentration measure (CONHT) (Van Oort & Atzema, 2004 p. 269). I used a location quotient, which measures the share of high-tech establishments in a region relative to the aggregated share of high-tech establishments in the Netherlands (see Table 12).

Table 11. Descriptive statistics on firm characteristics

	Description	Measurement	Mean	S.D.
FEMPGR	Firm employment growth	(ln (firm employment 2005)) – (ln (firm employment 2001))	1.18	1.13
CONSTANT	Constant	1	1.00	0.00
D15	Dummy reflecting time-frame 2001-2005 for firm growth measure	1 if growth is measured between 2001 and 2005 (0 otherwise)	0.35	0.48
D17	Dummy reflecting time-frame 2001-2007 for firm growth measure	1 if growth is measured between 2001 and 2007 (0 otherwise)	0.29	0.46
D57 (R)	Dummy reflecting time-frame 2005-2007 for firm growth measure	1 if growth is measured between 2005 and 2007 (0 otherwise)	0.36	0.48
DNEGRES	Dummy extreme negative residuals	1 if st. residual < -3.4 (0 otherwise)	0.00	0.06
DPOSRES	Dummy extreme positive residuals	1 if st. residual > 3.4 (0 otherwise)	0.01	0.09
AGE0402	Dummy age cohort 2002/2004	1 if year of startup within cohort (0 otherwise)	0.21	0.41
AGE01	Dummy age cohort 2001	1 if year of startup within cohort (0 otherwise)	0.09	0.28
AGE0099	Dummy age cohort 1999/2000	1 if year of startup within cohort (0 otherwise)	0.13	0.33
AGE9895	Dummy age cohort 1995/1998	1 if year of startup within cohort (0 otherwise)	0.17	0.38
AGE9483 (R)	Dummy age cohort 1983/1994	1 if year of startup within cohort (0 otherwise)	0.24	0.43
AGE82	Dummy age cohort before 1982	1 if year of startup within cohort (0 otherwise)	0.10	0.30
SIZE	Firm size	Ln (employment 2001)[b]	1.22	1.45

N= 1881; All variables in this table are measured on the on the firm level.

(R) = reference category; [b]: If employment was missing, I used the value for 2005,

Table 12. A Regional Concentration Measure

	Description	Measurement	Mean	S.D.
CONHT ^{REG}	Relative concentration of high-tech firms	(regional number of high-tech establishments 2001/ total number of regional establishments 2001)/ aggregated Dutch concentration	1.09	0.30

N= 1881; ^{REG}: This variable is measured on the regional level.

9.6 NETWORK DATA

The third set of explanatory variables contains network-related measures (NETW) that I used to test the hypotheses about networks as the mechanism behind spillovers. The relatively small number of firms with co-patents, and the distribution of these cooperations indicate that co-patenting is a rare occasion. Deriving regional-level characteristics based on these data lead to arbitrary indicators. Therefore, for the regional level aspect of networking this study focuses on regional-level association membership. For the firm-level characteristics, co-patent data are used, just as business association data.

Regional effects of network characteristics

To test the hypothesis on the regional level (H1), I used a measurement for the average number of business associations per establishment (ASSOPEST), as well as the average number of memberships per establishment, as proxies for regional network activity (MEMPEST) (see Table 13). These measures were also used to test the effect of regional network activity on individual firm performance (H2).

Table 13 Regional-Level Network Characteristics

	Description	Measurement	Mean	S.D.
MEMPEST ^{REG}	Regional average of the number of members per establishment	(Nr of memberships in a region/ Nr of establishments) x 100	1.73	0.32
ASSOPEST ^{REG}	Regional average of the number of business associations per establishment	(Nr of business associations in a region/ Nr of establishments) x 1000	0.45	0.77
AVNRMEM ^{REG}	Regional average of the number of memberships of firm participating in business associations	Average(number of memberships)	0.06	0.13

N= 11; ^{REG}: These variables are measured on the regional level.

To test the effect of individual networking activity on regional economic success (H3), the average number of memberships in a region (AVNRMEM) of firms participating in business associations was used as a proxy (Table 13).

Firm-level network measures

To test the impact of firm-level network characteristics on individual firm performance (H4), a dummy for ties via co-patenting (DPATCONTACT) was added. Moreover, I used a dummy for membership in any business associations (DMEM), membership in just one association (DMEM1), membership in more than one association (DMEM>1), and the absolute number of memberships (NRMEM).

As clarified in the theoretical part of this research, a network position that bridges structural holes is seen as a position with information advantages. Firms with memberships in more than two associations have such a bridging position; by connecting two or more associations, they can access different types of firms with different goals and different cultures. Other members can also potentially benefit from these firms through indirect contacts.

Diversity or homogeneity

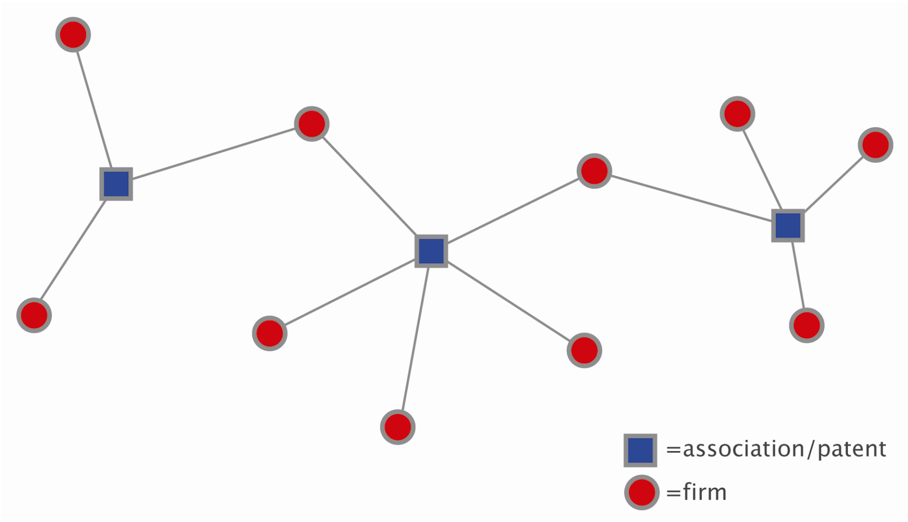
To examine the Marshall-Jacobs controversy over whether these spillovers via networks occur across similar or dissimilar types of firms (H5a and H5b), I used the following indicators. To test the diversity thesis (H5a, Jacobs), I counted all of the direct links to all other firms (ALLCONTACT1). Indirect contacts are also relevant because firms might indirectly benefit from firms with memberships in other clubs. Therefore, for all firms, I also include all indirect links to all other firms (ALLCONTACT2).

To conduct specialisation measurements (H5b, Marshall), I counted direct links to other high-tech firms (TECHCONTACT1) and indirect links via high-tech firms to all other high-tech firms through association membership (TECHCONTACT2). Ties via co-patents are another indicator of specialization. Therefore, PATCONTACT1 and PATCONTACT2 (direct and indirect contact via co-patents) were used.

The standard software packages, such as Ucinet and Pajek, do not provide analyses that combine both approaches. It is possible to count the number of direct ties with certain characteristics, but it is not possible to track indirect paths.

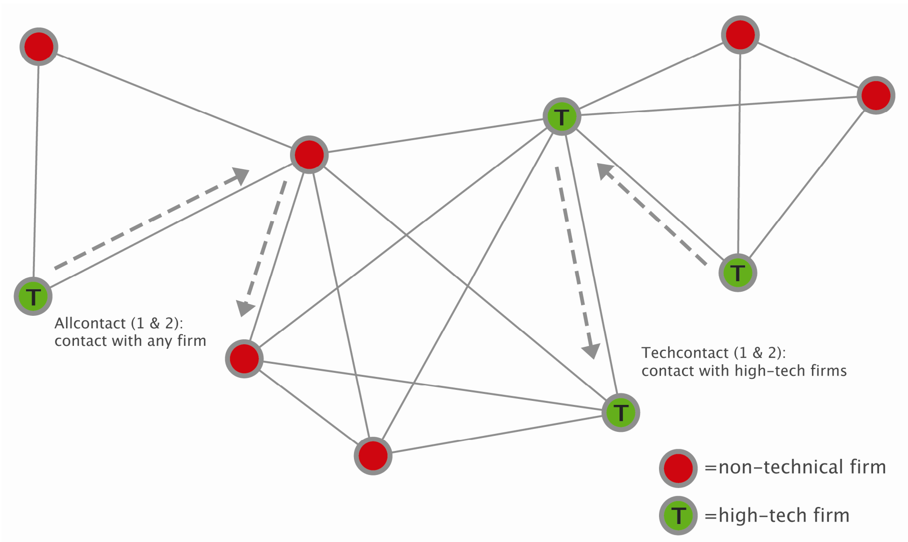
For this research, Pajek (Batagelj & Mrvar, 2008) was used to first convert the "clubs x firms" networks into one-mode "firms x firms" networks. Then, I read an attribute partition and removed the lines between firms with different scores by using the "remove lines between clusters" command. Calculating the degree scores for those firms resulted in the number of firms with the same attribute within one or two steps in the network.

Figure 23. Example of an Affiliation Network



By inverting the matrices behind the network graphs, which were presented in Chapter 8, I obtained firm x firm matrices. Co-members have a direct link in these matrices. I derived indirect network contacts by multiplying the matrices.

Figure 24. (Tech-) Contact in One and Two Steps



As a homogeneity measure, I counted direct links to other high-tech firms. Indirect measures were collected by calculating indirect ties via high-tech firms to other high-tech firms. I used direct and indirect links to all firms as an indicator of heterogeneity. Figure 25 presents a summary of these measures.

Figure 25. Summary of Individual Network Variables

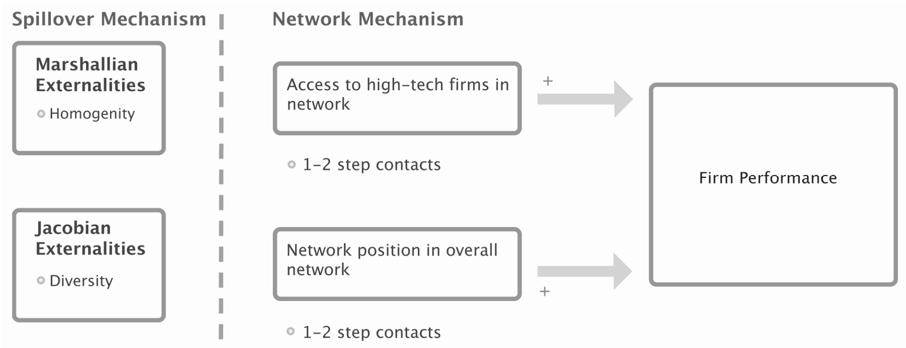


Table 14 lists variable names, measurements, and descriptives of the patent data that are used in the research model. Table 15 provides variable names, measurements, and descriptives of membership data. Table 16 contains a correlation table of the main variables in the model.

Table 14. Descriptives Patent Data

	Description	Measurement	Mean	S.D.
DPAT	Dummy applied for a patent	1 if nr. of patent applications>1	0.11	0.31
NRPAT	Number of patents	Ln (number of patents)	0.21	0.86
DPATCONTACT	Dummy patent contacts	1 if nr. of co-patents>1	0.01	0.08
PATCONTACT1	Direct ties, ties via co-patent network	Nr of 1-step contacts	0.011	0.15
PATCONTACT2	Indirect (2-step) ties to other firms	Nr of 2-step network contacts	0.010	0.14

N=2491; All variables in this table are measured on the on the firm level.

Table 15. Descriptives Membership Data

	Description	Measurement	Mean	S.D.
DMEM	Dummy member of an association	1 if member of one or more business associations(0 otherwise)	0.19	0.39
NRMEM	Number of memberships		0.29	0.79
DMEM1	Firm-level Dummy 1 membership	1 if member of one association (0 otherwise)	0.14	0.35
DMEM>1	Dummy more than one membership	1 if member of more than one association (0 otherwise)	0.05	0.22
ALLCONTACT1	Direct network ties to other firms in the regional network	Direct network ties/100	0.42	1.27
ALLCONTACT2	Indirect (2 steps) network ties to other firms in the regional network	Indirect network ties/100	7.64	18.90
TECHCONTACT1	Direct network ties to other high-tech firms in the regional network	Direct network ties/100	0.01	0.03
TECHCONTACT2	Indirect (2 steps) network ties to other high-tech firms in the regional network (via high-tech contacts)	Indirect network ties/100	0.03	0.10

N=563; (R) = reference category; All variables in this table are measured on the on the firm level.

Table 16. Correlations

	SIZE	NRMEM	ALLCONTACT1	ALLCONTACT2	TECHCONTACT1	TECHCONTACT2	FEMPGROWTH	AGE	LNNRPAT	CONHTRNL	CLUBPEST	MEMPEST	PATCONTACT1	PATCONTACT2
SIZE	1													
NRMEM	0.22	1												
ALLCONTACT1	0.21	0.91	1											
ALLCONTACT2	0.18	0.87	0.86	1										
TECHCONTACT1	0.16	0.82	0.71	0.8	1									
TECHCONTACT2	0.12	0.74	0.7	0.83	0.92	1								
FEMPGROWTH	0.76	0.2	0.18	0.16	0.15	0.11	1							
AGE	0.29	0.09	0.07	0.04	0.03	0.01	0.25	1						
LNNRPAT	0.2	0.22	0.15	0.14	0.19	0.14	0.2	0.16	1					
CONHTRNL	-0.01	0.11	0.1	0.14	0.1	0.09	0.01	-0.02	-0.02	1				
CLUBPEST	-0.01	0.37	0.33	0.4	0.33	0.33	0	-0.02	0.03	0.33	1			
MEMPEST	-0.01	0.34	0.3	0.37	0.28	0.26	0.01	-0.02	0.03	0.37	0.97	1		
PATCONTACT1	0	0.02	0	0.04	0.03	0.02	0	0.03	0.39	0.03	0.05	0.06	1	
PATCONTACT2	0.01	0	-0.01	0.01	0.01	0.01	0.01	0.07	0.34	0.01	0.05	0.06	0.8	1

N=1881

Chapter 10: Results [11]

10.1 INTRODUCTION

In this chapter, the sections successively present the following multilevel analyses results:

- The basic part of the multilevel model (10.2)
- The results of analyses on the regional level (H1, H2, H3) (10.3)
- The results of analyses on the firm level (H4, H5a, H5b) (10.4)

The firm-level results in Section 10.4, which contain network characteristics, are divided into: co-patent network data, results based on business association networks, and results of the model featuring both co-patent and membership networks.

10.2 BASIC PART OF THE MODEL

For the multilevel analysis, I used a random intercept model[12,13] in the MLWIN software (Rashbash, Browne, Healy, Cameron, & Charlton, 2008). I started with a model containing only a constant to test the regional effect (a so-called empty model, Model 1) (see Table 17). Then I entered the firm-level control variables of firm size, age, and economic sector for all of the firms in the 40 regions (Model 2). The declining -2*loglikelihood values across the models demonstrate that adding variables significantly improves the model[14].

Regional-level concentration variables were added to the third model. Table 17 indicates that there is no significant concentration effect for high-tech firms (CONHT) on firm employment growth. In the next step, I added a dummy to test for differences between the section of 11 selected regions and the entire population of these regions. The estimate[15] shows that no important differences between either subset can be found. This implies that for the applicable sectors, the regions I selected do not differ structurally from regions for which I do not have network information.

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[11] Parts of this chapter are published as (Boshuizen et al., 2009)

[12] A random slope model did not improve our results. The random slope effect was zero.

[13] Using an IGLS estimation.

[14] The -2*loglikelihood indicator provides a measure of the lack of fit between the model and the data. The difference between the deviance values of the two models indicates whether adding variables to the model improves the model (using a Chi-squared distribution) (Snijders & Bosker, 1999).

[15] (coef.: 0.008, s.e. 0.028)

Table 17. Results of the Basic Multilevel Analyses

Dependent variable: Firm employment growth (FEMPGROWTH)

(Variable names are explained in Tables 11 and 12 in chapter 9)

	Model 1		Model 2		Model 3		Model 4	
Fixed Part	COEF.	S.E.	COEF.	S.E.	COEF.	S.E.	COEF.	S.E.
CONSTANT	0,00	0,03	-0,71	0,20 ***	-0,71	0,20 ***	-1,39	0,58 ***
FIRM								
D15			0,41	0,04 ***	0,41	0,04 ***	0,45	0,08 ***
D17			0,48	0,04 ***	0,48	0,04 ***	0,54	0,08 ***
DNEGRES			-2,71	0,23 ***	-2,71	0,23 ***	-2,38	0,41 ***
DPOSRES			2,72	0,14 ***	2,72	0,14 ***	2,29	0,27 ***
31 Industry dummies (not show here)								
AGE0402[b]			0,31	0,05 ***	0,31	0,05 ***	0,44	0,10 ***
AGE01[b]			0,20	0,06 ***	0,20	0,06 ***	0,25	0,12 ***
AGE0099[b]			0,05	0,06	0,05	0,06	-0,03	0,11
AGE9895[b]			-0,04	0,05	-0,04	0,05	0,00	0,10
AGET82[b]			-0,15	0,07 ***	-0,15	0,07 ***	-0,10	0,13
SIZE 0[c]			0,45	0,10 ***	0,45	0,10 ***	0,54	0,18 ***
SIZE 1-9[c]			-0,16	0,07 ***	-0,16	0,07 ***	-0,09	0,13
SIZE 100-249[c]			0,46	0,12 ***	0,46	0,12 ***	0,25	0,24
SIZE 250-499[c]			0,64	0,20 ***	0,63	0,20 ***	0,69	0,36 **
SIZE 500-999[c]			0,72	0,21 ***	0,73	0,21 ***	0,05	0,52
SIZE 999+[c]			1,10	0,27 ***	1,10	0,27 ***	0,57	0,38 *
SIZE[a]			0,54	0,03 ***	0,54	0,03 ***	0,56	0,06 ***
SIZE x AGE0402[a,d]			-0,32	0,03 ***	-0,32	0,03 ***	-0,29	0,06 ***
SIZE x AGE01[a,d]			-0,07	0,04 **	-0,07	0,04 **	-0,05	0,10
SIZE x AGE0099[a,d]			0,00	0,03	0,00	0,03	0,08	0,06
SIZE x AGE9895[a,d]			0,04	0,03	0,04	0,03	0,05	0,05
SIZE x AGET82[a,d]			0,02	0,03	0,02	0,03	0,06	0,05
CONC								
CONHT[a, REG]					0,01	0,04	-0,03	0,08
Random effects								
Regional level variance U_j	0	0	0	0	0	0	0	0
Firm level variance R ij	1,275	0,042	0,290	0,009	0,290	0,009	0,275	0,016
-2*loglikelihood:	5794,8		3012,4		3012,3		870,3	
N- regional level	40		40		40		11	
N- firm level	1881		1881		1881		563	

REG: These variables are measured on the regional level, the others on the firm level

a: Variables are centered around the grand mean

b: Reference category: AGE9483

c: Dummies for size category, based on "SIZE"; Reference category: SIZE 10-99

d: Reference category: SIZE x AGE9483

*** significant at the 0.01 level

** significant at the 0.05 level

* significant at the 0.10 level

(1-sided testing)

The intraclass correlation of the four models is zero. This demonstrates that no variance in the model can be attributed to the regional level[16]. This means that high-tech firms in the 40 regions do not differ structurally from one another.

The results are not dependent on outliers since leaving out cases with high Leverage or Mahalanobis values did not alter the results. To err on the side of caution, the cases with the largest residuals were absorbed into a dummy[17].

10.3 EFFECTS OF REGIONAL PARTICIPATION CHARACTERISTICS

The first two hypotheses about the effects of regional-level participation on average performance (H1) and individual firm performance (H2) are analysed using membership data.

The number of regions (11) with this type of network data is too small to allow for a full regression analysis. To provide a sense of network participation and average regional firm performance, Figures 26 and 27 show linear curve-fits of the number of members per establishment (MEMPEST) and the number of associations per establishment (ASSOPEST).

The graphs show that both measures seem to be positively related to average regional performance. However, in both cases, the number of cases and the b-values and explained variances are too small to draw a clear conclusion. Moreover, the positive tendency is in both graphs caused by region 5 (Southwest- Friesland), region 7 (North-Drenthe), and region 24 (Gooi en Vechtstreek). When these regions are removed, the positive tendencies diminish.

To test the implications of regional network participation on the firm level, the effects of the two variables were added to the multilevel model that was introduced earlier.

From the fourth model onward, I focused on the 11 selected regions. Models 5 to 8 (see Tables 18, 19, and 20) contain network measures. The network variables are correlated because they all indicate social interactions. Therefore, I entered these indicators separately.

[16] The intraclass correlation measure can be used to calculate what percentage of the variance is explained at the regional level (Snijders and Bosker, 1999).
[17] Standardized residuals smaller than -3.4 or larger than 3.4 are left out.

Figure 26. Members per Establishment and Growth

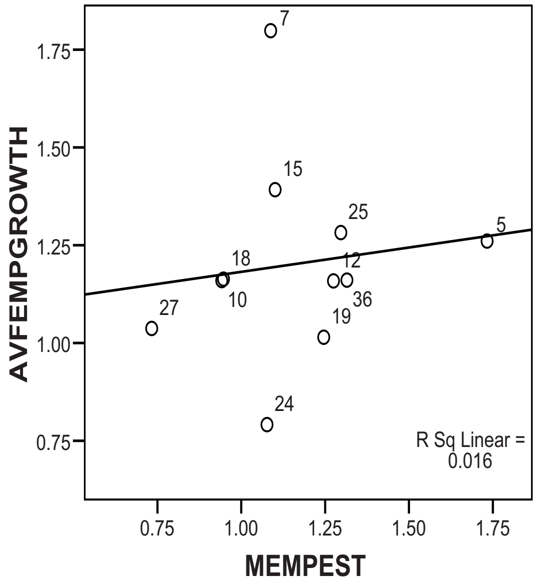
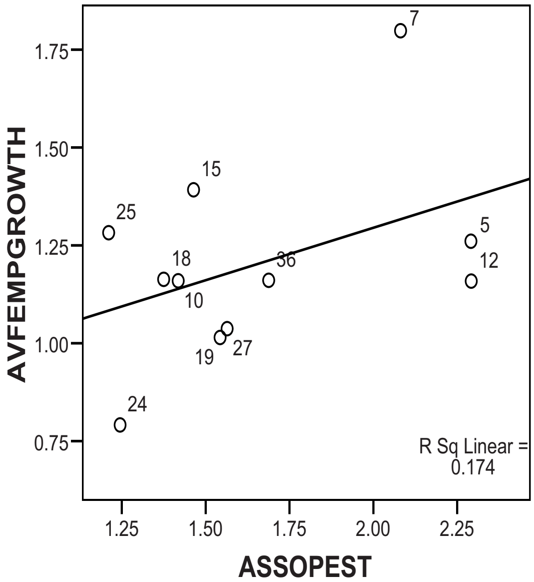


Figure 27. Associations per Establishment and Growth



N=11; a: 0.759 se. 0.330 sig. 0.047; b: 0.268 se. 0.195 sig. 0.201; R^2: 0.174, F: 1.900 sig. 0.201; Region numbers: 5: Southwest-Friesland, 7: North-Drenthe, 10: Northwest-Overijssel, 12: Twente, 15: Arnhem/Nijmegen, 18: Den Helder, 19: Alkmaar, 24: Gooi en Vechtstreek, 25: Leiden-Bollenstreek, 27: Delft-Westland, 36: Southwest North-Brabant.

The results in Table 18 indicate that there is a small, but not always significant, negative effect of the regional network activity (MEMPEST & ASSOPEST) on firm growth when the model is further expanded. Due to the small number of observations on the regional level, the estimates have to be treated with caution. It is striking that the effect on the individual firm level is the opposite of the aggregate regional effect. In reviewing the results of Figures 26 and 27, the multilevel results and the low intraclass correlation, a positive effect could not be detected. Therefore, the first two hypotheses have to be rejected. Regional membership participation does not seem to influence performance on the individual (H2) or regional levels (H2).

Table 18. Results of Multilevel Analysis with Regional Measures

Dependent variable: Firm employment growth (FEMPGROWTH)

(Variable names are explained in Tables 11, 12, 13 in Chapter 9)

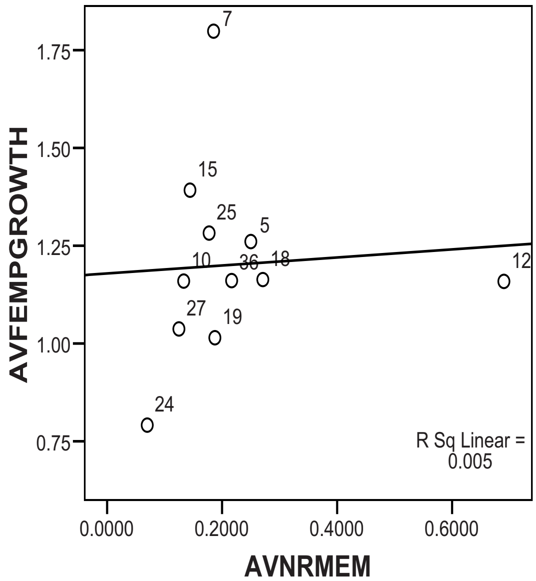
	Model 4		Model 5a		Model 5b	
Fixed Part	COEF.	S.E.	COEF.	S.E.	COEF.	S.E.
CONSTANT	-1,39	0,58 ***	-1,38	0,59 ***	-1,26	0,58 ***
FIRM						
D15	0,45	0,08 ***	0,45	0,08 ***	0,46	0,08 ***
D17	0,54	0,08 ***	0,54	0,08 ***	0,53	0,08 ***
DNEGRES	-2,38	0,41 ***	-2,39	0,41 ***	-2,38	0,41 ***
DPOSRES	2,29	0,27 ***	2,28	0,27 ***	2,29	0,27 ***
31 Industry dummies (not show here)						
AGE0402[b]	0,44	0,10 ***	0,44	0,10 ***	0,43	0,10 ***
AGE01[b]	0,25	0,12 ***	0,25	0,12 ***	0,24	0,12 ***
AGE0099[b]	-0,03	0,11	-0,03	0,11	-0,04	0,11
AGE9895[b]	0,00	0,10	0,00	0,10	-0,01	0,10
AGET82[b]	-0,10	0,13	-0,10	0,13	-0,11	0,13
SIZE categories (not shown here)						
SIZE x AGE interactions (not shown here)						
CONC						
CONHT[a, REG]	-0,03	0,08	-0,03	0,08	-0,05	0,08
NETW						
MEMPEST[a, REG]			-0,015	0,126		
ASSOPEST[a, REG]					-0,138	0,068 ***
Random effects						
Regional level variance U_j	0	0	0	0	0	0
Firm level variance R ij	0,275	0,016	0,275	0,016	0,273	0,016
-2*loglikelihood:	870,3		870,3		866,2	
N- regional level	11		11		11	
N- firm level	563		563		563	

REG: These variables are measured on the regional level, the others on the firm level
a: Variables are centered around the grand mean
b: Reference category: AGE9483

*** significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.10 level
(1-sided testing)

The third hypothesis presumes that individual participation in networks has a positive effect on regional performance. This hypothesis was tested using the average number of memberships (AVNRMEM) of firms participating in business associations as an indicator and, again, this hypothesis was tested using a linear curve fit. Figure 28 seems to indicate that there is a tendency for the average number of memberships to have a small positive effect on average firm performance. In this graph, again, regions 7, 12, and 24 determine this effect. Leaving these three regions out makes the effect disappear. As a result, the third hypothesis must be rejected.

Figure 28. Average Number of Memberships and Growth



N=11; a: 1.179 se. 0.844 sig. 0.00; b: 0.103 se. 0.509 sig. 0.844; R^2: 0.005, F: 0.41 sig. 0.844; Region numbers: 5: Southwest-Friesland, 7: North-Drenthe, 10: Northwest-Overijssel, 12: Twente, 15: Arnhem/Nijmegen, 18: Den Helder, 19: Alkmaar, 24: Gooi en Vechtstreek, 25: Leiden-Bollenstreek, 27: Delft-Westland, 36: Southwest North-Brabant.

10.4 FIRM-LEVEL RESULTS

In this second part of the results section, I focus on the individual-level firm results. I used both the co-patent network and the business association networks to investigate the individual-level hypotheses (H4 and H5a/H5b).

Results: Patent networks

Network ties via co-patents are the first indicator used to test the effect of network participation on firm performance (H4).

The results of Model 6a (Table 19) indicate that patenting firms (DPAT) do not differ from firms without patents. The results of Model 6b indicate that, with all other aspects being equal, the number of patents (NRPAT) has a negative effect on firm performance. The results of Model 7a show that there is no effect of having co-patents (DPATCONTACT). The number of other high-tech firms that are accessible via co-patents in one step (PATCONTACT1), or in two steps (PATCONTACT2), is an indicator that was used for both the fourth and fifth hypotheses. The results of Model

7b and 7c (Table 19) indicate that both direct and indirect contacts via co-patents have no impact on firm performance.

Results: Networks of Business Associations

Business association networks are the second indicator used to test hypotheses 4 and 5. One should note that being a member of a business association is a prerequisite for having a number of memberships or contacts. Therefore, the effect of, for example, the number of memberships (NRMEM) and the number of direct contacts (ALLCONTACT1) needs to be summed with the effect of being a member of any association (DMEM) (see Table 20; Models 8b and 8e).

In line with hypothesis 4, I found a small, positive, statistically significant effect of membership variables on firm performance. The most important one, member of any association (DMEM), shows a positive significant effect on firm growth. This means that members of a business association generally perform better than non-members. Estimates on the effect of the number of memberships (NRMEM), membership in one association (DMEM1), and membership in more than one association (DMEM>1) do not paint a different picture. Their additional effect is smaller and insignificant. Accordingly, I had to accept the fourth hypothesis.

The results compiled in Table 20 also show that I did not find any evidence that both direct and indirect contacts (ALLCONTACT 1&2) lead to enhanced firm performance. The estimates are not significant; they are small, and they concern indirect contacts in the wrong direction. Therefore, based on the membership data, hypothesis H5a (Jacobs) was clearly rejected. However, concerning the Marshall thesis, I observed a small positive effect of contacts on high-tech firms (both direct and indirect) (TECHCONTACT 1&2) on firm performance. Therefore, hypothesis H5b (Marshall) could not be rejected, based on the membership data.

Table 19. Multilevel Results with Patent Data

Dependent variable: Firm employment growth (FEMPGROWTH) (Variable names are explained in Tables 11, 12 and 14 in Chapter 9)

	Model 6a		Model 6b		Model 7a		Model 7b		Model 7c	
Fixed Part	COEF.	S.E.	COEF.	S.E.	COEF.	S.E.	COEF.	S.E.	COEF.	S.E.
CONSTANT	-0,71	0,20 ***	-0,71	0,20 ***	-0,71	0,20 ***	-0,71	0,20 ***	-0,71	0,20 ***
D15	0,41	0,04 ***	0,41	0,04 ***	0,41	0,04 ***	0,41	0,04 ***	0,41	0,04 ***
D17	0,48	0,04 ***	0,48	0,04 ***	0,48	0,04 ***	0,48	0,04 ***	0,48	0,04 ***
DNEGRES	-2,71	0,23 ***	-2,71	0,23 ***	-2,71	0,23 ***	-2,71	0,23 ***	-2,71	0,23 ***
DPOSRES	2,72	0,14 ***	2,71	0,14 ***	2,72	0,14 ***	2,72	0,14 ***	2,72	0,14 ***
AGE0402[b]	0,31	0,05 ***	0,32	0,05 ***	0,31	0,05 ***	0,31	0,05 ***	0,31	0,05 ***
AGE01[b]	0,20	0,06 ***	0,20	0,06 ***	0,20	0,06 ***	0,20	0,06 ***	0,20	0,06 ***
AGE0099[b]	0,05	0,06	0,05	0,06	0,05	0,06	0,05	0,06	0,05	0,06
AGE9895[b]	-0,04	0,05	-0,04	0,05	-0,04	0,05	-0,04	0,05	-0,04	0,05
AGET82[b]	-0,15	0,07 ***	-0,15	0,07 ***	-0,15	0,07 ***	-0,15	0,07 ***	-0,15	0,07 ***
31 Industry dummies (not show here)										
SIZE categories (not shown here)										
SIZE x AGE interactions (not shown here)										
CONC										
CONHT[a, REG]	0,01	0,04	0,01	0,04	0,01	0,04	0,01	0,04	0,01	0,04
NETW										
DPAT	-0,03	0,04	-0,10	0,06 **	-0,04	0,04	-0,04	0,04	-0,04	0,04
NRPAT[a]			0,04	0,03 **						
DPATCONTACT					0,08	0,16	0,31	0,42	0,11	0,27
PATCONTACT1[a]							-0,19	0,33		
PATCONTACT2[a]									-0,02	0,15
Random effects										
Regional level variance U_j	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Firm level variance R ij	0,29	0,01	0,29	0,01	0,29	0,01	0,29	0,01	0,29	0,01
-2*loglikelihood:	3011,7		3008,8		3011,5		3011,1		3011,5	
N- regional level	40		40		40		40		40	
N- firm level	1881		1881		1881		1881		1881	

REG: These variables are measured on the regional level, the others on the firm level
a: Variables are centered around the grand mean
b: Reference category: AGE9483

*** significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.10 level
(1-sided testing)

Combination of patent and membership data

The results of Model 9a and 9b (Table 21) indicate that adding patenting characteristics to the model with only business association networks does not alter the outcomes of the model. Adding co-patenting characteristics also has no influence on the other variables in the model (these results are omitted from the table). This indicates the robustness of the results in Tables 19 and 20. Because no effect of co-patenting on firm performance could be found, the conclusions are based on the results of the analysis of business association membership.

Table 20. Multilevel Results with Business Associations Networks

Dependent variable: Firm employment growth (FEMPGROWTH) (Variable names are explained in Chapter 9 in Tables 11, 12, 13, 15)

	Model 4		Model 8a		Model 8b		Model 8c		Model 8d	
Fixed Part	COEF.	S.E.	COEF.	S.E.	COEF.	S.E.	COEF.	S.E.	COEF.	S.E.
CONSTANT	-1,39	0,58 ***	-1,35	0,58 ***	-1,35	0,58 ***	-1,35	0,58 ***	-1,35	0,58 ***
FIRM										
D15	0,45	0,08 ***	0,45	0,08 ***	0,45	0,08 ***	0,45	0,08 ***	0,45	0,08 ***
D17	0,54	0,08 ***	0,54	0,08 ***	0,54	0,08 ***	0,54	0,08 ***	0,54	0,08 ***
DNEGRES	-2,38	0,41 ***	-2,35	0,41 ***	-2,35	0,41 ***	-2,35	0,41 ***	-2,35	0,41 ***
DPOSRES	2,29	0,27 ***	2,31	0,27 ***	2,31	0,27 ***	2,31	0,27 ***	2,31	0,27 ***
31 Industry dummies (not show here)										
4 age categories (not shown here)										
SIZE categories (not shown here)										
SIZE x AGE interactions (not shown here)										
CONC										
CONHT[a, REG]	-0,03	0,08	-0,03	0,08	-0,03	0,08	-0,03	0,08	-0,03	0,08
NETW										
DUMMEM			0,177	0,063 ***	0,162	0,096 **	0,151	0,117 *	0,185	0,069 ***
NRMEM[a]					0,011	0,053				
DMEM1							0,034	0,127		
DMEM>1									-0,034	0,127
ALLCONTACT1[a]										
ALLCONTACT2[a]										
TECHCONTACT1[a]										
TECHCONTACT2[a]										
Random effects										
Regional level variance U_j	0	0	0	0	0	0	0	0	0	0
Firm level variance R ij	0,275	0,016	0,271	0,016	0,271	0,016	0,271	0,016	0,271	0,016
-2*loglikelihood:	870,3		862,5		862,5		862,4		862,4	
N- regional level	11		11		11		11		11	
N- firm level	563		563		563		563		563	

	Model 8e		Model 8f		Model 8g		Model 8h	
Fixed Part	COEF.	S.E.	COEF.	S.E.	COEF.	S.E.	COEF.	S.E.
CONSTANT	-1,36	0,58 ***	-1,35	0,57 ***	-1,36	0,58 ***	-1,36	0,58 ***
FIRM								
D15	0,45	0,08 ***	0,45	0,08 ***	0,45	0,08 ***	0,45	0,08 ***
D17	0,54	0,08 ***	0,53	0,08 ***	0,54	0,08 ***	0,54	0,08 ***
DNEGRES	-2,36	0,41 ***	-2,35	0,41 ***	-2,35	0,41 ***	-2,35	0,41 ***
DPOSRES	2,31	0,27 ***	2,31	0,27 ***	2,31	0,27 ***	2,31	0,27 ***
31 Industry dummies (not show here)								
4 age categories (not shown here)								
SIZE categories (not shown here)								
SIZE x AGE interactions (not shown here)								
CONC								
CONHT[a, REG]	-0,03	0,08	-0,03	0,08	-0,03	0,08	-0,03	0,08
NETW								
DUMMEM	0,159	0,080 ***	0,302	0,107 ***	0,159	0,078 ***	0,162	0,076 ***
NRMEM[a]								
DMEM1								
DMEM>1								
ALLCONTACT1[a]	0,010	0,027						
ALLCONTACT2[a]			-0,003	0,002 *				
TECHCONTACT1[a]					0,466	1,171		
TECHCONTACT2[a]							0,109	0,292
Random effects								
Regional level variance U_j	0	0	0	0	0	0,002	0	0,002
Firm level variance R ij	0,271	0,016	0,270	0,016	0,271	0,016	0,271	0,016
-2*loglikelihood:	862,4		860,5		862,3		862,4	
N- regional level	11		11		11		11	
N- firm level	563		563		563		563	

a: Variables are centered around the grand mean

REG: These variables are measured on the regional level, the others on the firm level

*** significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.10 level
(1-sided testing)

Table 21. Multilevel Results with Patents and Membership Networks

Dependent variable: Firm employment growth
(FEMPGROWTH) (Variable names are explained in Table 11, 12, 14, 15 in Chapter 9)

	Model 9a			Model 9b		
Fixed Part	COEF.	S.E.		COEF.	S.E.	
Fixed Part						
CONSTANT	-0,71	0,20	***	-0,71	0,20	***
D15	0,41	0,04	***	0,41	0,04	***
D17	0,48	0,04	***	0,48	0,04	***
DNEGRES	-2,71	0,23	***	-2,71	0,23	***
DPOSRES	2,72	0,14	***	2,72	0,14	***
AGE0402[b]	0,31	0,05	***	0,31	0,05	***
AGE01[b]	0,20	0,06	***	0,20	0,06	***
AGE0099[b]	0,05	0,06		0,05	0,06	
AGE9895[b]	-0,04	0,05		-0,04	0,05	
AGET82[b]	-0,15	0,07	***	-0,15	0,07	***
31 Industry dummies (not show here)						
SIZE categories (not shown here)						
SIZE x AGE interactions (not shown here)						
CONC						
CONHT[a, REG]	0,01	0,04		0,01	0,04	
NETW						
DPAT	-0,03	0,11		-0,03	0,11	
NRPAT[a]	0,03	0,04		0,03	0,04	
DMEM	0,17	0,06	*	0,17	0,10	*
NRMEM[a]				0,00	0,06	
Random effects						
Regional level variance U_j	0,00	0,00		0,00	0,00	
Firm level variance R ij	0,27	0,02		0,27	0,02	
-2*loglikelihood:	862,04			862,04		
N- regional level	11			11		
N- firm level	563			563		

REG: These variables are measured on the regional level, the others on the firm level
a: Variables are centered around the grand mean
b: Reference category: AGE9483

*** significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.10 level
(1-sided testing)

Chapter 11: Conclusion

This study has formed an attempt to open the "black box" of knowledge spillovers by investigating both formal and informal relationships among high-tech firms in Dutch regions. It has investigated whether localized knowledge spillovers can be explained by inter-firm interactions that are conducive to firm performance. The results confirm that inter-firm networks indeed serve as a mechanism for knowledge spillovers.

An overview of the wider research in the field of spatial agglomerations and knowledge spillovers suggests that firms in a region do benefit from knowledge spillovers, but how micro-level interactions result in these spillovers remains unclear. Nevertheless, it is generally assumed that network contacts are one of the mechanisms behind localized knowledge spillovers.

More precisely, inter-firm networks are identified as drivers of firm success due to the resources embedded in these networks, which are often labelled as social capital. Two views dominate concerning the outcomes of these knowledge spillovers: they can be either a public advantage or an individual asset for the firms involved. The view that stresses a generally cooperative atmosphere within a region assumes that social capital provides a public advantage for all the firms in a region. Conversely, when social capital is seen as being embodied in inter-firm networks it becomes an individual resource for firms.

Research Question

To test this view, the question as to whether inter-firm linkages are a mechanism for knowledge spillovers must be answered.

Logically, the composition of a network should have an impact on increased firm performance through knowledge spillovers. Social network methods and theory can be used to investigate the link between interactions and localized knowledge spillovers. In the wake of the Marshall and Jacobs controversy (Van der Panne, 2004), the question has become whether such knowledge spillovers occur between similar or dissimilar types of firms.

The general research question was answered in this thesis using five hypotheses concerning the regional level, the firm level, and the interaction between these two levels.

H1: The more network participation there is within a region, the better the performance of that region.
H2: The more network participation there is within a region, the better the individual performance of firms within that region.
H3: The more that individual firms participate in regional networks, the better the performance of a region.
H4: The more that individual firms participate in regional networks, the better their individual performance.
H5a (Jacobs): The more that the network contacts of firms are sector-diverse (i.e. links to firms outside their own sector), the better the individual performance of firms.
H5b (Marshall): The more that the network contacts of firms are sector-specific (i.e. links to firms within their own sector), the better the individual performance of firms.

Design and data

To explain regional-level and individual-level performances, based on regional and individual level resources, a multilevel approach is required to obtain robust estimators.

The data for the multilevel analysis covered four areas. First, firm information at the establishment level (i.e. employment growth) for all high-tech Dutch firms within all 40 Dutch regions; second, regional economic statistical information; third, patent data for all Dutch regions, which was used to measure knowledge spillovers through co-patent networks; and, fourth, network data derived from membership registrations of all the business associations in 11 selected regions. The structure of the data enabled an analysis of network data on a larger scale than previous studies.

Results

The first-time large-scale analysis of cooperative patents within the Netherlands shows that this formal type of network cooperation occurs much less frequently than suggested in the literature. Co-patenting only occurred in a small number of cases, clustered around a few large firms and, moreover, appeared to involve sparsely connected, country-wide networks rather than to be a result of regional cooperation.

The second part of the data collection focused on business association networks. The analysis of these data, performed on a larger scale than in previous studies shows that a minority, only 17%, of high-tech firms participate in regional business associations.

The multilevel analysis failed to uncover any regional effects, either within the 11 regions where both types of network characteristics had been obtained or in the entire population of 40 regions with more limited data. Although high-tech firms are not distributed evenly across the country, contrary to expectations, their performances do not differ. In other words, high-tech firms do not appear to differ from region to region.

Given the findings of previous studies, the fact that the current study has found no effect of regional-level network participation on firm performance, either at the regional level (H1) or on the individual level (H2), is a surprise. Both these hypotheses are therefore rejected. There is some evidence that individual involvement in regional associations has a small positive effect on regional performance, although the evidence is insufficient to accept or reject the third hypothesis.

On the individual level, co-patent networks have only a negligible, and statistically non-significant, effect on firm performance. Therefore, if using co-patents as the criteria, the individual level hypotheses (H4, H5a, H5b) would be rejected. Given the small effect and the apparent rarity of regional co-patenting in the Netherlands, the conclusion must be that co-patenting is an inappropriate vehicle for measuring inter-firm cooperation.

A more clear-cut outcome is that participation in business associations does have a positive impact on employment growth within a firm, confirming Hypothesis 4. This result supports the idea that inter-firm interaction is one of the mechanisms that drives knowledge spillovers. This is an important result for spillover research because it is one of the first studies to explicitly link these aspects.

Results relating to the last hypothesis, which addresses the Marshall-Jacobs controversy, reject the Jacobs hypothesis (H5a) and favour the Marshall hypothesis

(H5b), which could not be rejected. For high-tech firms, local links to similar firms appear to be more advantageous than links to dissimilar firms.
The investigation of co-patenting as an indicator for inter-firm networks shows that it is has no effect on firm performance. The results on knowledge exchange through more informal inter-firm networks indicate that knowledge exchange fostered by business association membership does take place, but the effect is weak.

Discussion

A striking finding of this study is the paucity of co-patenting networks. A reason for this could be that the Netherlands is too small for such regional networks to serve any useful purpose and that international co-patenting occurs more frequently. Another reason for the sparseness of the co-patent network could be that the study has focused on the high-tech sector. However, since high-tech firms are especially active in R&D and therefore patenting, it seems unlikely that more patents would be found in other sectors. Another possible reason for the limited number of co-patents is that (following Hagedoorn (2003)) firms prefer to have full control over patents. Therefore, to achieve this, firms may prefer to split a joint discovery into a series of separate patents.

An unexpected result of this study is that regional effects have not been found. This is true for all Dutch regions. Similar results were observed in the sample of 11 regions. Although only 11 of the 40 regions were studied in depth, this is still a rather large number compared to previous studies, which were restricted to just one, two, or sometimes three regions. Further, in this study, the selected regions to measure business association membership have maximum variability on the share of high-tech firms, the existence of a university, geographic location, and urban density. The regional network characteristics do show that the regions do indeed differ within the Netherlands. Therefore, despite the sample being limited to 11 regions, it seems highly unlikely that the individual-level results would have been different if all 40 regions had been included.

A legitimate question is whether the selected NUTS-3 level is the appropriate unit of analysis for a study of knowledge spillovers. One could argue that larger regions are a more appropriate aggregated level for this sort of subject although there are several counter-arguments. Firstly, the NUTS-3 regions do include complete firm networks: only in a very few instances did the investigated regional associations have members from beyond the region. Also, when firms were members of several associations these were nearly always all within their NUTS-3 border. This fact shows that firms clearly focus on contacts within their region. This seems remarkable given the short geographical distances and easy access between the regions.

In this study, only Dutch high-tech firms have been investigated and therefore the question arises as to whether it is possible to generalize the results. In many ways, the Netherlands, as an industrialized country, resembles its neighbours. Particularly of relevance here, is that the participation rates in associations in neighbouring countries are similar (Morales & Geurts, 2007). This suggests that the results obtained here are also relevant for other Western countries.
The selection of high-tech firms is another decision that can be challenged. The justification put forward is the general assumption that it is especially high-tech firms that benefit from cooperative relationships. On this basis, a critical mass will be reached earlier in this sector than elsewhere. It remains an interesting question for future research as to whether this mechanism is relevant to all sectors.

The results indicate that social contacts among firms are important in facilitating knowledge spillovers. However, a critical issue is that membership of business associations, although this does provide an easy way to come into contact with other firms, only indicates "potential ties" of firms rather than indicating direct network contacts. More research is required to investigate the role of business association membership in greater detail. Research could, for example, investigate the kind of information exchanged at network meetings and how the function of these meetings evolves over time in the different development phases of a firm.

Despite the probably conservative choice of business association membership as a proxy for personal networks, a positive effect at the individual level has been found. The question is whether the results would have been different if personal associations had also been considered.

Individual membership by CEOs of organizations such as the Lions Club and other rotary and sports clubs represents another way to potentially access new information. Professional associations can also provide contacts and information of great value for entrepreneurs. It is quite possible that membership rings overlap such that entrepreneurs that meet through a business association also share involvement in certain personal associations. If memberships do not overlap, the fact of belonging to a combination of business and personal associations will lead to a wider network than solely considering business associations would suggest. On the regional level, it remains to be seen whether a higher participation rate would result in a regional advantage for firms. Although these non-business types of networks were excluded from this research, and therefore no data have been collected related to them, it seems likely that a greater network effect on the individual-level would have been found had they been considered. Personal or business contacts outside a business association can, of course, also provide entrepreneurs with valuable information. Unfortunately, it would be very difficult to collect data on such links on the scale of the study attempted here.

Although this study clearly indicates the relevance of business associations as a source of information for entrepreneurs, future research should focus on the content and, to a lesser extent, the frequency and intensity of network contacts in order to reach a fuller understanding of their importance.

The type of network measures adopted here are another point for discussion. Using fairly simple network data, i.e. only one- and two-step contacts, has the advantage of being less sensitive to missing data than measures involving centrality that take a larger part of the network into account.

The direction of causality is a standard issue in social science. Given the nature of the current study, it is not possible to completely rule out the possibility of reverse causality. However, based on both social capital theory and regional economic theories, the presumption that membership of associations can provide access to the resources that firms need seems reasonable. In fact, an explicit aim of many business associations is to enhance mutual learning and business.

The geographical scale of contacts is an issue that was raised in the theoretical part of this research. It is argued here that long-distance and short-distance contacts are not mutually exclusive. It is unreasonable to assume that if regional ties matter, distant ties are irrelevant, or vice versa. Following the line of reasoning that distant contacts are achievable for all firms, whereas regional contacts are only achievable for firms in close vicinity, regional contacts can make a difference and are therefore more important to firms.

This study shows the potential for further research on inter-firm networks. By using data on co-patenting networks and business association networks, and connecting them to regional and firm performance on a larger scale than previous studies have done, this research reveals inter-firm networks to be one of the micro-foundations behind knowledge spillovers.

Regional economic policy is often based on the assumption that knowledge spillovers take place in both formal and informal inter-firm relationships. However, the results reported here indicate that governments should be cautious in basing their policies on such an assumption. Although support has been found for inter-firm networks as drivers of individual firm performance, the effect seems to be rather small and only effective at the level of the individual firm: no regional effect could be detected. In other words, it is doubtful whether policy that stimulates participation in business associations or other types of inter-firm relations has an effect on the region as a whole although a limited group of firms might well benefit.

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Summary in Dutch / Nederlandse Samenvatting

Netwerkcontacten worden vaak gezien als belangrijke bron van concurrentievoordelen voor bedrijven en als verklaring voor regionaal economisch succes. De voordelen van netwerken, bijvoorbeeld als basis voor kennisuitwisseling, zijn echter nauwelijks bewezen door empirisch onderzoek. De onderzoeksresultaten in dit proefschrift bevestigen de voordelen van netwerkcontacten voor individuele bedrijven. Een effect van netwerken op regionaal economisch succes wordt echter niet gevonden.

Door het uitbreken van de economische crisis in 2008 is de vraag hoe de economie gestimuleerd kan worden relevanter dan ooit. Bij het opstellen van economisch beleid, dat vaak gericht is op innovatie, dient Silicon Valley dikwijls als voorbeeld. Dit regionale cluster van high-tech bedrijven staat bekend om de netwerkrelaties tussen bedrijven die beschouwd worden als belangrijke verklaring voor het innovatieve succes van deze regio. Hoewel onderzoek op dit terrein toeneemt, is het verband tussen netwerkrelaties en regionaal economisch succes nauwelijks door onderzoek aangetoond. Desondanks is economisch beleid er steeds vaker expliciet op gericht om formele en informele contacten tussen bedrijven te bevorderen. Er bestaan bijvoorbeeld subsidies voor gezamenlijk onderzoek en ontwikkeling door bedrijven. Ook wordt door de aanleg van bedrijvenparken voor specifieke branches geprobeerd om door nabijheid samenwerking en kennisuitwisseling te stimuleren.

“Kennisspillovers” (vrij vertaald betreft dit het “overspatten” van kennis tussen bedrijven) zijn een belangrijk concept in de regionaal economische theorie (Hoofdstuk 2). Tot voor kort deden economen kennisspillovers af als “iets dat in de lucht hangt”, waarvan alle bedrijven in een regionaal cluster profiteren. Steeds vaker worden de voordelen van kennisspillovers toegeschreven aan netwerken waarbinnen kennis wordt uitgewisseld. Deze studie onderzoekt of de rol van regionale netwerken als infrastructuur voor de verspreiding van kennis inderdaad bestaat.

Onderzoeksvraag:
Zijn netwerkcontacten tussen bedrijven een mechanisme voor kennisspillovers?

Bestaand onderzoek op het gebied van regionale clusters is vaak beschrijvend van aard. Het onderzoek is daarbij meer gericht op het vatten van regionale clusters in ideaaltypen en typologieën dan op empirische toetsing om het achterliggende mechanisme te begrijpen (Hoofdstuk 3). Dit is bijvoorbeeld het geval bij de Marshall-Jacobs controverse. Marshall aan de ene kant benadrukt de voordelen van clusters van gelijksoortige bedrijven, terwijl Jacobs de voordelen van diversiteit beschrijft. Beide mechanismen sluiten elkaar echter niet uit.

De verbinding tussen micro-mechanismen als verklaring van macro-fenomenen is een belangrijke element in dit onderzoek (Hoofdstuk 4). Sociale netwerken zijn daarbij de belangrijke schakel.

Uitgangspunt is dat het sociaal kapitaal dat zich in netwerken bevindt bedrijven verrijkt met kennis die belangrijk is voor hun ontwikkeling (Hoofdstuk 5). Vaak wordt ervan uitgegaan dat de voordelen van (sociale) netwerken niet alleen gelden voor individuele bedrijven, maar dat het effect ervan uitstraalt naar de regionale economie als geheel. Dat zou betekenen dat ook bedrijven die geen deel uitmaken van deze netwerken toch indirect zouden profiteren van hun aanwezigheid.

Volgens sociale netwerk methoden en theorie is het aannemelijk dat de samenstelling van de regionale netwerken van invloed is op kennisuitwisseling, en daarmee op de prestaties van bedrijven (Hoofdstuk 6). De Marshall-Jacobs controverse wordt onderzocht met de vraag of kennisuitwisseling bestaat door netwerkcontacten tussen gelijksoortige of tussen verschillende typen bedrijven.

Dit onderzoek test hypothesen op het regionale niveau, het bedrijfsniveau en de interactie tussen beide niveaus (Hoofdstuk 7):
H1: Hoe meer netwerkparticipatie er in een regio bestaat, hoe beter de prestaties van die regio.
H2: Hoe meer netwerkparticipatie er in een regio bestaat, hoe beter de individuele prestaties van bedrijven in die regio.
H3: Hoe meer individuele bedrijven participeren in regionale netwerken, hoe beter de prestaties van een regio.
H4: Hoe meer individuele bedrijven participeren in regionale netwerken, hoe beter hun individuele bedrijfsprestaties.
H5a (Jacobs): Hoe diverser de sectoren van netwerkcontacten (contact met bedrijven buiten de eigen sector), hoe beter de individuele prestaties van bedrijven.
H5b (Marshall): Hoe sector-specifieker de sectoren van netwerkcontacten (contacten met bedrijven in de eigen sector), hoe beter de individuele prestaties van bedrijven.

Onderzoeksontwerp
Het onderzoek is gebaseerd op vier databronnen (Hoofdstuk 8). Ten eerste zijn gegevens op het bedrijfsniveau voor alle Nederlandse high-tech bedrijven gebruikt (bijvoorbeeld medewerkersgroei). Er is voor high-tech bedrijven gekozen omdat juist voor deze bedrijven de toegang tot kennis essentieel wordt geacht voor hun succes.
Ten tweede is gebruik gemaakt van regionale statistische gegevens op het NUTS-3 niveau. De derde gegevensbron betreft patentregistraties voor alle Nederlandse regio's. Om kennis uitwisseling te meten zijn uit deze patentgegevens netwerkcontacten gedestilleerd gebaseerd op patenten die in samenwerking tussen bedrijven zijn aangevraagd (co-patenten). De vierde belangrijke datacomponent bestaat uit netwerkgegevens die zijn afgeleid uit lidmaatschappen van bedrijvenverenigingen in 11 geselecteerde Nederlandse regio's. De structuur van de data maakte een analyse mogelijk op een grotere schaal dan in eerdere studies het geval was.

Om economisch succes zowel op regionaal- als op individueel bedrijfsniveau te kunnen verklaren, is een multi-level regressieanalyse gebruikt (Hoofdstuk 9). In deze analysemethode kunnen de effecten op beide meetniveaus gelijktijdig worden geschat en worden robuuste schatters verkregen.

Resultaten

Uit de grootschalige analyse van Nederlandse patentsamenwerkingen blijkt dat deze formele vorm van samenwerking veel minder vaak voorkomt dan vaak wordt verondersteld (Hoofdstuk 10). Co-patenten worden slechts in een klein aantal gevallen gebruikt en zijn geclusterd rond een paar grote bedrijven. De onderzochte bedrijven zijn slechts in beperkte mate onderling verbonden via co-patenten. Tevens blijkt het afgeleide netwerk niet zozeer het resultaat te zijn van regionale samenwerking, maar eerder de nationale schaal te weerspiegelen.

Het tweede deel van het onderzoek richtte zich op (informele) netwerken die zijn afgeleid van lidmaatschappen van bedrijvenverenigingen. Uit de analyse, die is uitgevoerd op een veel grotere schaal dan eerdere studies, blijkt dat slechts een minderheid van 17% van de high-tech bedrijven participeert in regionale bedrijvenverenigingen.

De multilevelanalyse heeft geen regio-effecten kunnen aantonen. Het effect ontbrak zowel voor de 11 geselecteerde regio's waarbinnen beide typen netwerkgegevens zijn verzameld als voor de 40 regio's met beperktere gegevens. Hoewel high-tech bedrijven niet gelijkmatig over Nederland verdeeld zijn, blijken hun prestaties niet te verschillen tussen regio's.

Gegeven de resultaten van eerder onderzoek komt het ontbreken van een effect van regionale netwerkparticipatie, op zowel het regionale niveau (H1) als op het individuele niveau (H2), als een verrassing. Door dit resultaat moeten beide hypothesen verworpen worden. Hoewel er aanwijzingen zijn voor een klein positief effect van individuele betrokkenheid in bedrijvenverenigingen op de regionale prestaties, is het effect te beperkt om de derde hypothese aan te nemen of te verwerpen.

Op het individuele niveau blijken co-patenten slechts een verwaarloosbaar en statistisch niet significant effect op bedrijfsprestaties te hebben. Met co-patenten als criterium zouden de hypothesen op het individuele bedrijfsniveau (H4, H5a, H5b) moeten worden verworpen. Uit het minimale effect en de zeldzaamheid van co-patenten in Nederland blijkt dat co-patenten ongeschikt zijn als methode voor het meten van samenwerking tussen bedrijven.

De resultaten van de multilevel-analyse bevestigen dat (informele) netwerkcontacten via bedrijvenverenigingen de prestaties van bedrijven positief beïnvloeden. Daarmee vormen netwerken een basis voor kennisuitwisseling tussen bedrijven, en wordt Hypothese 4 bevestigd. Dit resultaat is van belang omdat het een verband aantoont tussen netwerkcontacten van bedrijven en bedrijfsprestaties.

De resultaten voor de laatste hypothese, die toegespitst zijn op de Marshal-Jacobs controverse, leiden tot het afwijzen van de Jacobs hypothese (H5a) ten gunste van de Marshall hypothese (H5b), die niet verworpen kan worden. Voor high-tech bedrijven blijken lokale contacten met gelijksoortige bedrijven belangrijker te zijn dan contacten met bedrijven uit afwijkende sectoren.

Conclusie

De analyse van informele netwerkcontacten toont aan dat deze contacten een positief effect hebben op bedrijfsprestaties. Echter, dit effect blijkt beperkt te zijn tot individuele bedrijven en niet uit te stralen naar gehele regio's (Hoofdstuk 11). Dit betekent dat alleen individuele bedrijven profiteren van deelname aan bedrijvenverenigingen. Dit effect wordt gevonden, ondanks de conservatieve maat van lidmaatschap van bedrijvenverenigingen als benadering van persoonlijke netwerkcontacten.

Formele samenwerking op het gebied van patenten blijkt slechts in beperkte mate voor te komen en geen invloed te hebben op bedrijfsprestaties.

De resultaten van dit onderzoek bieden nieuwe inzichten op het gebied van kennisuitwisseling als motor van de regionale economie. Regionaal economisch beleid is vaak gebaseerd op de aanname dat kennisuitwisseling plaatsvindt via formele en informele netwerkcontacten. Uit de resultaten van dit onderzoek blijkt dat deze aanname niet zomaar te rechtvaardigen is. Hoewel een positief effect wordt gevonden van netwerkrelaties op individuele bedrijfsprestaties blijft het effect slechts beperkt en heeft het geen invloed op de regio als geheel. Het is onwaarschijnlijk dat beleid ter stimulering van relaties tussen bedrijven een effect heeft op de regio als geheel. Slechts een kleine groep bedrijven profiteert van dit soort maatregelen.

Epilogue / Nawoord

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Laat de nieuwe avonturen maar komen!

Johannes Boshuizen
Enschede, April 2009

Social networks are frequently claimed to provide advantages to firms, but rarely has this been empirically demonstrated. It is generally assumed that networks benefit not only individual firms, but also the regional economy as a whole. Localized knowledge spillovers are seen as the basis of these gains. This study investigates whether the role of social networks, as the 'tubes' through which knowledge spills over and flows, does indeed provide benefit. The starting point of this study is the idea that the social capital embodied in these networks strengthens firms, giving them knowledge that supports their development. Both formal and informal networks are studied here.

A part of the empirical data for this study derives from a large-scale analysis of cooperative patents within the Netherlands. The results of this analysis show that this formal type of network cooperation occurs much less frequently than is widely assumed and, furthermore, that they appear to have no effect on the performance of high-tech firms.

The second part of the data collection focused on business association networks. The analysis from this data, performed on a larger scale than in previous studies, confirms that informal inter-firm networks are one of the micro-foundations of knowledge spillovers. However, their effects appear to be limited to individual firms and do not extend to regions as a whole. This implies that only individual firms benefit from participation in business associations. The results of this study thus provide new insights into the mechanisms behind knowledge spillovers as drivers of a regional economy.

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