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It's a Small World: Efficiency in a SME network across Design and Technology

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ABSTRACT

This paper analyzes connectivity and efficiency of a SME network across two industries. These characteristics are likely to be different for networks of various industries. The concept of ‘small worlds’ is used to judge overall network efficiency. The actual network can be classified as one in which a small world is present. Visualization of the results shows a single core group in the network. It was found that non-profit as well as science actors were overrepresented in the core of the field.

INTRODUCTION

Over the past decades, alliance networks have proven to be vital to firms. While most of the attention in the literature has been paid to the alliance activities of large multinational corporations, especially small and medium sized enterprises (SMEs) seem to benefit from the opportunities associated with strategic partnering. In their effort to survive and overcome resource scarcities small and medium sized enterprises are increasingly looking for competent partners that provide them with complementary assets and resources. In today's dynamic environment no company can seem to afford to go it alone (Porter, 2000; Hagedoorn, 2002). In particular in high-tech sectors, technological dynamics are so fast that almost no single firm is able to keep up with their rapid changing environments on their own (Duysters, 2001). Small innovative firms even tend to rely more heavily on technological developments outside the firm than large firms in their efforts to obtain new knowledge (Hicks and Hedge, 2005). Smaller firms have undoubtedly less resources of their own than large firms, but they generate more innovative output than expected. Their relations with others provide information about opportunities in their environment and enable them to exploit knowledge spillovers (Audretsch and Lehmann, 2005).

The growing importance of networks requires that SMEs thoroughly understand its characteristics, so they can use this knowledge to their own advantage. Although SMEs are believed to provide vital energy and stimulate growth

(Heilbroner, 1984; Schumpeter 1934) and recently regain popularity as topic in literature and policy-making programs (Audretsch and Thurik, 2001; Shane and Venkataraman, 2000; OECD, 2000), theory regarding SMEs and networks is still underdeveloped (Pittaway et al., 2004). Until now most research concentrates on personal networks of SMEs. There is a lack of empirical research concerning structural aspects of the network as a whole (Shaw, 2006) and in particular on network structures that span sectors (De Jong et al., 2005; Hagedoorn, 2002). We therefore take a social network perspective in order to describe the structural network characteristics of a SME network, in particular at network and subgroup level. Examining the actual network of SMEs will provide insight into the connectivity and efficiency of SME networks. These characteristics are likely to be different for networks of various industries. In this paper we will use the concept of 'small worlds', as used in the field of graph theory (Cowan and Jonard, 2004; Watts, 1999), to judge overall network efficiency. A network with small world properties displays enhanced knowledge diffusion speed. As shown in the work of Verspagen and Duysters (2004) the concept unites two well-known perspectives in social network theory; the perspectives regarding social capital and structural holes (Walker et al., 1997). We will therefore investigate whether the constructed network can be classified as a highly connected, a highly fragmented or a small world. The efficiency of the actual network can be compared to other industry networks and thus can be valued. Furthermore we will examine the structure of the network in terms of sub-communities. Of interest is to investigate how sub-communities relate to small worlds. Such an investigation will enhance the theory of small worlds.

We will examine SME network data between design en high-tech industries in the Southeast Netherlands. The acknowledgement of the importance of design in product development has been resulting into an increase of efforts of various parties to establish co-operations between design and high-tech organizations. By this study we aim to gain a better understanding of these efforts and to reduce the bias in the literature towards large companies and their alliance networks.

The study will also provide insights to regional politics. According to the EU being a knowledge economy is the way to stay competitive in the world. The EU stimulates transnational co-operations between companies, research institutions and universities in order to boost knowledge transfer, innovation capacity and eventually economic welfare in the EU. Goals of national programs are derived from the overall goal. The South of Netherlands concentrates on being a top-technology region in which new products and services of economic value are created (OP-Zuid, 2007). Value should be created by adding an opinion, identity or experience to products and services (Innovatieplatform, 2005). However parties can find each other insufficiently. Government stimulates the funding of intermediaries to overcome these market imperfections. Special attention is prearranged to research for SMEs and entrepreneurship. Regarding these goals it is interesting for politics to receive ideas on *how* co-operations can be stimulated best. For that they need to know how organizations cooperate at present. Is knowledge transferred in an efficient way, are there partnership concentrations and who is involved in co-operations.

Our study contributes to the existing literature in the following ways: First, it is one of the few contributions that take an inter-sectoral approach by considering the existing social network of SMEs between two different sectors, i.e. design and high-tech industries. Second, it is the first attempt to actually construct the Design-Technology network in a social network way. No such data was available before in the Netherlands. Third, by highlighting the general structure of the network across these sectors, the study identifies the opportunities and constraints faced by the members of this network. This generates significant scientific and managerial implications. Network theory regarding small worlds will be enhanced as well because our insights contributes to the still infant field that studies the efficiency of partnerships in SME networks.

This paper is structured as follows. In the literature review section we provide a brief overview of the social network perspective and we introduce the field in which the research takes place. Next, the methodology used to explore the SME network is described. The research question is then addressed in section 4 and 5. We will end with the main conclusions and a discussion of the findings.

THEORETICAL BACKGROUND

Social network theory; a structural approach

The history of modern technological development shows that innovation is above all a process in which large and small companies need to cooperate. Firms realize this; various industries are showing increasing interaction among firms. A large part of interactions can be classified as strategic technological alliances among large firms (Hagedoorn, 2002). Due to their growth, these alliances have been the focus of most research. Interactions among SMEs have not been investigated much, although their importance in change processes was already recognized by Schumpeter (1934). Today most governments seem to recognize the pivotal role played by SMEs. They are generally considered as the backbone of society (EC, 2003) and the drivers of exploration and exploitation of opportunities (Shane and Ventaraman, 2000).

Literature that does investigate SME networks has traditionally concentrated on personal networks and their influence on their competitive position and ultimately success (O'Donnell et al., 2001). Networks are viewed as a strategic way to get access to resources and reduce costs in order to seize opportunities in an increasingly turbulent market. The same tendency is seen in overall network literature. This stream of research based on the resource-based perspective (Wernerfelt, 1984; Williamson, 1991; Combs and Ketchen, 1999), sees firms as the motor of change and focus on reasons for alliance formation. It is concerned with determining why and when networks are formed.

How networks are formed has been less frequently subject of research, particular in the context of SMEs. Such research concentrates mainly on with whom a firm cooperates. Not the firm, but its various social relations are the focus of attention. The network is seen as endogenous; a factor of influence on a firm as well as a result of a firm's own influences (Schumpeter, 1934). Theory based on the network perspective builds on the general notion that economic actions of firms are influenced by the social context in which firms are embedded and that actions can also be influenced by the position of actors in social networks (Gulati, 1998). Contrary to the resource-based view, it takes into account the idea that a network has its own nature and creates opportunities for firms. Still, SME research does not focus on entire networks and amplifies the underlying processes dynamics (O'Donnell et al., 2001). Little attention has been given in SME literature to entire networks, the underlying processes dynamics and to cooperation as a support strategy to discover and exploit opportunities (Shaw, 2006; Hanna and Walsh, 2002; O'Donnell et al., 2001; Johannisson, 1997).

In order to understand the characteristics of the network a deep understanding of social network processes is needed (Gulati and Gargiulo, 1999; Gulati, 1998). Social network theory describes these social dynamic processes between parties (Granovetter, 1973; Scott, 2000). The theory is centrally concerned with questions related to with whom a firm collaborates (Scott, 2000)[1]. A few concepts associated with network theory are well-known: strong and weak ties (Granovetter, 1973) and the aspects of structural holes and social capital. Strong ties are related to bonding capital; weak ties are related to bridging capital (Fernandez and Nichols, 2002). The central debate in this literature is focused around the basic arguments stemming from Burt's (1992) structural holes argument and Coleman's (1988) closure argument. Burt (1992) suggests that firms that who are able to build bridges between previously unconnected dense, i.e. redundant, parts of the network (Burt, 1992; Walker et al., 1997) will likely enjoy brokerage advantages based on access to non-redundant high yield information (see also Rowley et al., 2000). Alternatively, Coleman (1988) argues that being part of a densely knitted (redundant) network brings important advantages because of the degree of intimacy and trust in these densely connected areas.

There is ambiguity within the academic literature regarding the appropriate kind of social capital in various fields of industries. Research suggests that both forms of social capital have to be present within networks, because firms want to efficiently absorb knowledge as well as create novelty (Gilsing et al., 2006; Ahuja, 2000; Cohen and Levinthal, 1990). This idea is in line with the work of March (1991). In order to grow companies depend on both creating new

[1] Granovetter's paper "the strength of weak ties" of 1974 drew attention to the theoretical orientation giving quantitative comments on the structure of networks.

possibilities and exploiting what is already known. Tushman and O'Reilly (1996) compared this to the eyes of the god Janus who had two sets of eyes; one pair for looking behind and one pair which focused on the issues ahead. In the context of SMEs, network literature conveys that the focus should not be on getting more and more, strong relations, but also on diversity in relations (Zahra and Hayton, 2004). It has been argued that the most successful organizations are those that are ambidextrous in nature in the sense that they are successful in both exploiting existing competencies and also in exploring new innovations (Sadowski et al., 2008).

The theory of small worlds can be seen as a model that unites the two perspectives (Verspagen en Duysters, 2004). A small world is a part of a network in which a couple of actors are relatively highly connected, but also have a considerable amount of relations outside the connected group. A small world therefore combines also the best of both perspectives. Cowan and Jonard (2004) define a small world as an identifiable region of space of structures in which knowledge diffusion is much more complete than elsewhere. Having high levels of social capital is beneficial for local knowledge diffusion and exploitation. Having also a relatively high portion of bridging capital that span structural holes is beneficial for global knowledge diffusion between various groups.

There is a lack of small world research regarding the relation between specific subgroups and the efficiency of a network, especially in the area of economics

(Ozman, 2009; Watts, 2004). An industry network consists of relations between various parties: profit and non-profit companies, science organizations, governmental relations, etc. Furthermore various parties can have multiple roles, like that of supplier as well as customer. However research mostly studies only supplier networks or supplier – customer networks in a specific domain (Pittaway et al., 2004). It is interesting to investigate in what way various parties are related to a small world. In order to give a description of those who are relatively well connected, the full richness of relations in the network need to be studied.

Hypothetical network structures;
Theory and Concepts of Small Worlds

In the work of Watts (1999) the small world model is explained by describing two extreme worlds first. The caveman world is one, completely connected group. In such a world “everybody you know, knows everybody else you know and no one else” (p. 43). When a stranger enters the group, this person has to get acquainted with only one other person of the group in order to get fully connected with the total group. A cavemen world can be seen as a representation of the pure social capital perspective. On the other extreme, represented by the Moore graph, everybody lives isolated and interact via computers. Even if two persons in this world would engage in a personal connection, this world would still stay highly disconnected. The Moore graph can be related to the structural holes perspective of Burt (1992).

A small world is a network in which the two extreme worlds find an optimal balance. In a small world clustering of actors is high, but at the same time the characteristic path length between actors is relatively short[2]. In addition to high levels of bonding capital, there are just enough bridging relations to compose a balance.

In terms of advantages, a small world obtains the best of both social capital perspectives. In a Moore graph the network has a random local structure, but short paths between actors. New knowledge in such a world travels fast at first. But the process slows down relatively fast when the knowledge which is to spread reaches high levels of complexity. In a caveman world the network is locally highly structured, but path lengths are long. Diffusion of new knowledge is slower than in the Moore graph, but the process continues longer, and knowledge can more fully exploited. Small world networks show advantages of both: because this part of the network has relatively short path lengths, diffusion in the early periods is relatively fast; because of local clustering, knowledge

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[2] Average path length is the average number of steps separating two randomly chosen actors in a network. Characteristic path length is the median of average path length of all actors in the network.

A cluster can be determined by the number of actual relations in a part of a network divided by the maximum relations possible in that particular part. Clustering at the level of the network as a whole is defined as the average of clustering of all parts in the network (Watts, 1999).

exchange continues longer than it does in random worlds (Cowan and Jonard, 2004).

In reality social networks will have characteristics of both worlds. Local clustering and path length will be intertwined, but when can we speak of the presence of a small world? To trace what small world ratio is present in actual networks we need to know more about how many bridging relations are present in an overall network. To find that out we can make use of the concept shortcuts. In graph theory bridging relations are described as shortcuts. Shortcuts connect two actors which otherwise would be separated. It is represented by parameter Φ, the fraction of bridging relations in a graph that are shortcuts. Path length and clustering size can be contrasted with the concept of shortcuts. As shown in figure 1, lines of path length and clustering size are drawn as a function of parameter Φ. The graph shows the path from many shortcuts to very few shortcuts, i.e. the path from a strict social capital perspective to a strict structural holes perspective, in which the variables clustering and path length have different slopes. Note that the lines are not predictions, but theoretical calculations representing levels of intensity regarding 'random partner seeking'.

At low levels of Φ (many shortcuts) high levels of path length en clustering are shown. This corresponds to the caveman world. At high levels of Φ (few shortcuts) the opposite is shown. The latter corresponds to the Moore graph. We can see that for rather low levels of Φ E [0.01, 0.1] path length and clustering diverge in a most optimal manner; characteristic path length is short, the amount of clustering is relatively high. In other words, an actual network has small world properties when at low levels of Φ, local clustering is much larger than the theoretical Moore graph and characteristic path length approximately equals the theoretical Moore graph values (see Watts, 1999, for more details).

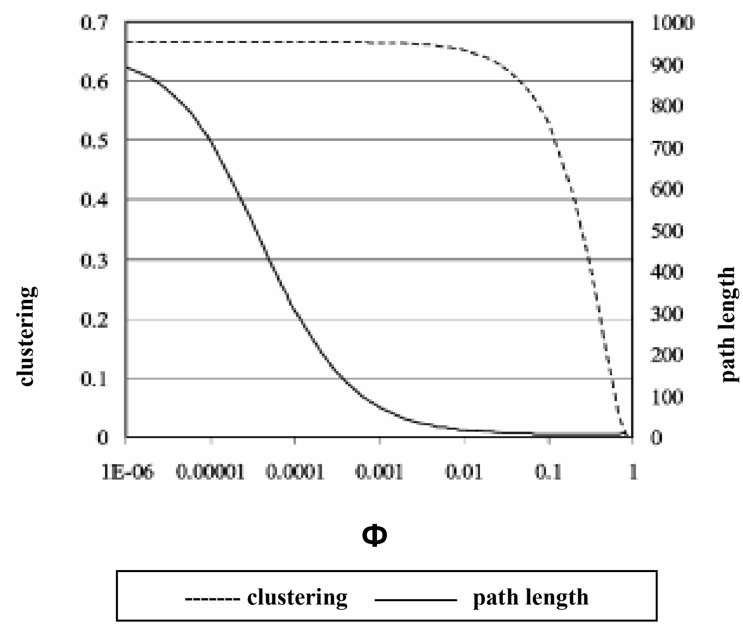

Figure 1. Length and clustering contrasted with parameter Φ, the fraction of bridging relations in a graph that are shortcuts.

The concept of shortcuts to determine the ratio of bonding and bridging capital in a network is useful for our research; parameter Φ can be seen as a degree of presence of the structural holes in the overall network formation.

Research question

The presence of small worlds provides insights into connectivity and efficiency of a network. As shown in the previous section the small world of a certain network can be mathematical constructed. Such a construct provides some benchmark against which we can compare values of the actual practice. Empirical research will enhance our knowledge about the ratio of social capital and structural holes present in various fields of industries. How do the structural network characteristics of actual networks as a whole look like? Ambiguity about the appropriate kind of social capital that should be present in networks can be diminished.

Our first research question is how actual networks compare to the hypothetical network structures mentioned in social network theories. As in the work of Verspagen and Duysters (2004) we will study whether the actual network is one with high levels of bonding capital, high levels of bridging capital or whether it can be classified as a small world. The efficiency of the actual network can be compared with other industry networks and thus we will be able to put a value on the relative efficiency of the whole network. Of interest is to see whether the networks of SMEs are different in social network terms compared to large firms or other sectors.

Our second research question will address the structure of actual networks in terms of sub-communities. In reality multiple small worlds can occur in a network as well as none. If more local cores exist, subgroups will probably be formed around these cores. Studying sub-communities will provide more in-depth knowledge about the way bonding and bridging capital are balanced. Our second research question is to what extend are subgroups identifiable within the actual network. A sub-question to this is the extend to which subgroup identities are useful to describe at least one possible core of the emerging field. Such detailed information will provide insights into the involvement of subgroups in building social capital as well as bridging structural holes. SMEs operating in a network with multiple cohesive groups will face different network efficiency and opportunities than when they operate in a more polarized network structure.

RESEARCH DESIGN

Research setting

This study will construct the network of SMEs across design and high-tech industries[3] in order to see their particular structure design. We will look into inter-firm relations of so-called transitory alliances; direct relations between two and three actors. We define a transitory alliance as a particularly short-lived non-equity alliance that focuses on completing narrowly defined tasks in a very short time frame. These kinds of inter-firm relations are established in dynamic industries because equity-based alliances do not deal effectively with turbulent environments (Duysters and de Man, 2003).

The design and high-tech industries are dynamic environments. These sectors become more and more important in modern economy (Jacobs, 2005). Recent government studies in the Netherlands and Great Britain emphasize the importance of the creative industries[4] of which the design sector is a part. The design sector is part of the creative industries and ascribes to our research. It is a sector which shows the necessity to cooperate in order to develop meaningful

[3] High-tech industries in the Southeast Netherlands consist of medical technology, high tech systems, automotive, nano & microsystems, ICT and the field of design & technology and new materials. The area is an important driver for the Dutch economy, contributing 15% of gross domestic product, 30% of industrial employment and almost 40% of the added value of total Dutch manufacturing industry (Sistermans, 2005).

[4] The creative industries are a wide-ranging industry including:

- Art & heritage sector: plastic arts, stage arts, musea, cultural festivals
- Media and entertainment: television, radio, publishing, film, music industry, popular festivals
- Creative business services: fashion, design, games, architecture, advertising.

Creative activities are defined as innovative activities that create value by adding a meaning, identity or experience to products or services (Innovatieplatform, 2005; DCMS, 2001).

products. The creative industry is known for its short product cycles, risky projects and fast changes in production processes. Their social network is built on the principles of collaboration, participation, exploration and exploitation (Hartley, 2005). Furthermore it is a sector which mainly consists of SMEs which not have been subject of much research regarding networks.

Design becomes increasingly important to high-tech products. The Southeast Netherlands is a top technology region of Europe which also shows a concentration of design firms. In this region design is seen as ‘business creator’; involved in developing and exploiting new ideas. Designers in this region are asked to join firms at a very early stage of the innovation process (TNO, 2005).

The region itself has a high concentration of elite knowledge and cooperation between a wide variety of organizations: SMEs, whole education and research stream, large-scale industry and knowledge institutions (Sistermans, 2005). The Southeast Netherlands will be the starting point of our research.

Methodology

To get closer insights into the network of the design and high-tech industries in the Southeast Netherlands, a survey was conducted. People working in the field of design and/or technology were invited to participate in the research. The fields design and technology were not specified in the survey, because the aim of the study is to investigate the network between the industries, not to compare them. It was up to respondents to decide how they interpret these fields and their own work. The aim was to map the most important work relations between people who are active in the subsequent fields. In order to take into account the full richness of relations in the network the respondent had to identify who was important to them. It was not possible to identify upfront who is involved in what way in the network. Of special interest were the roles of strong and weak ties.

Respondents were asked to mention the names and organizations of at most ten of their Dutch business partners who had an important (qualitative) influence on their business performance the last five year. To identify the strong and weak ties respondents were asked to rank the persons they mentioned. Partners who were most important to their business results during the last five years had to be put at the top of the listing. In addition, they had to specify the role of the partner (customer, supplier, advisor, college of other company, researcher) and the kind of influence of the partner (innovation/knowledge, marketing, organization, finance) on their business performance. The extra information about organization names and the content of relations enabled us to describe the most important work relations in the network in various ways, not only in this article, but also to the field itself.

The limitation of five years was added to get insights in the present state of affairs since the industries are dynamic environments. Only Dutch partners are considered because the network would get too wide spread and fragmented. Besides the studies interest goes out to the area of Southeast Netherlands.
The survey will include questions that provide relevant background information of participants. Other background information will be gathered by desk research.

The survey was initially sent to a selected group of people involved in design as well as in technology. The respondents were asked to provide the names of business partners with whom they have the aforementioned relationship. E-mail addresses of people listed or organization names were asked for. If e-mail addresses were missing, a search for e-mail addresses was performed on the internet or inquiries were made. Everybody who was listed in the response also received an invitation to fill in the survey. Several waves have been set in motion to collect data. This snow ball technique[5] is developed to identify hidden members and relation patterns (Hanneman and Riddle, 2005). In case of the design and high-tech industries, especially designers are a rather hidden population. Some work in firms, some work as part-time freelancer, some have their own firms. This technique was a useful way to get a clearer picture of their network and relations.

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Sample and Data

Since the population is a rather hidden one, it is hard to say something about the representativeness of the sample for the total group of people in the fields.
For the initial sample set we selected organizations from a chamber of commerce list and further specified our sample on basis of internet company descriptions. We chose to send the owner or managing director the invitation, since they play a leading role in SMEs (MacGregor, 2004). It was important to carefully select the first sample set. A homogeneous sample set was needed, meaning when set in motion the 'snowball' was not send in a certain direction.

We started sending out the questionnaire in January 2007. The results represent the network between design en high-tech industries and correspond to the database at July 29th 2007. At this point there were 468 names in the database. 405 persons received an invitation to participate (63 names were mentioned in the last wave and have not been mailed yet, 16 e-mail addresses were not available for the remaining persons, 16 people were mailed in the first wave, but whished not to participate). 104 useful responses were obtained (25,7% of the invited people). The results reported in this paper are based on the database consisting of these respondents.

Social network analysis is used to answer the research questions. The results are used to describe the structural characteristics of the network and not to make statements. A macro analysis requires complete network data; the presence of all relations of the whole population. We would need a 100% response rate to collect the complete network information. Such information can not be realized when using questionnaires and therefore hard statements about structural characteristics can not be made. However the response rate is sufficient to be able to draw a clear picture of the actual network.

How the actual network between design and high-tech industries compares against the theoretical model is described below.

RESULTS

The various characteristics of the industries imply that the actual network will show small world properties. Note that we do not compare the two industries, but look at the network between them. The high-tech sector as well as the design sector is known for its creativity. Exploration of knowledge is important; relations with people who have relatively unfamiliar knowledge play an important role when generating ideas. The presence of bridging capital between the two industries would be expected. On the other hand, local collaboration is important in both fields too. Interactions with other fields such as design may still be preliminary, suggesting that a more loosely connected network will be present. In short, both industries are dynamic and build on the principles of exploitation and exploration, co-operations between high-tech and design industries are stimulated, the Southeast area is an elite knowledge area which is attractive enough to hold on to employees (Sistermans, 2005). Small world features should be present in the actual network.

To answer the first research question and find out how the actual network between design and high-tech industries compares against the theoretical model we made calculations for the fields together. The calculations for the actual clustering coefficient (γ) and the characteristic path length (L) between connected actors are shown in table 1. We had to dichotomize and symmetrize the valued data in order to be able to calculate values that are comparable with the theoretical values. Furthermore when considering the network, we concentrated on the parts of the network that are connected. Results are therefore related to the principal component of the network (440 actors).

				Actual		Caveman		Moore graph	
	Φ	N	K	L	γ	L	γ	L	γ
Actor-level	0,834	440	2,523	6,059	0,178	62,093	0,473	8,993	0,006

Table 1.Network statistics of the network between design and high tech industries

When putting these values in a graph we see how the network structure compares to the benchmarks of the random network with varying Φ. Figure 2 shows how the theoretical lines contrast with the clustering coefficient and the characteristic path length (the dots) of the actual network. The theoretical graph shown in figure 1 is based on a random chosen network size and average number of direct connections of actors. Also, the underlying model assumes that the amount of connections of actors do not differ too widely from each other. In real cases these assumptions may just not be present. Consequently, for a certain observed value of Φ, path length and local clustering values of an actual network may be positioned off the theoretical curves.

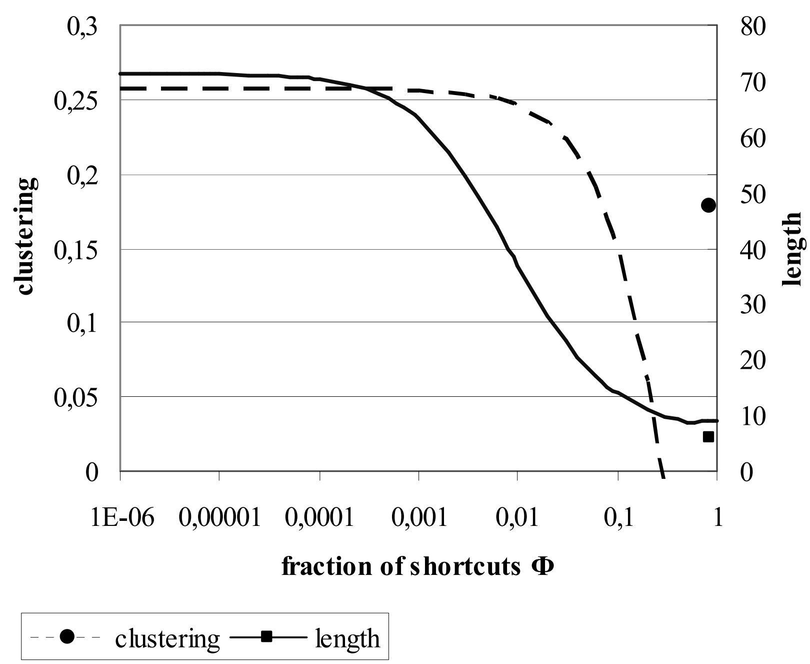

Figure 2. Network benchmark contrasted with statistics actual network (principal component)

We observe that the value for L is below the theoretical curve. This indicates that network length is smaller than in a random network. Clustering is higher than the benchmark value. Hence, we conclude that there is a tendency for strong bonding capital.

So, is the network characterized by a small world in which distinct clusters are weakly connected to each other? The high value for clustering indicates that social capital is important in the field. On the other hand path length is below the Moore value, indicating a tendency for strategic partner seeking in line with the structural holes perspective. Consequently we can conclude that the network between design and high tech industries shows small world properties. The low path length indicates the presence of efficient knowledge flows, high clustering of efficient knowledge exploitation.

Subgroups in the network Design and High-tech SMEs

The actual network seems to contain a few people with high connectivity. We do not know yet how these people are structured at a sub-level. Does the network indicate that multiple sub-communities (small worlds) are present? In other words do these people represent two distinct industries or not. There is evidence that the industries increasingly interact. Design is becoming more and more important in product development. Technology has to look good in order to be sold. Furthermore qualitative research reports that the network of design is very fragmented; loosely connected (Innovationplatform, 2005). A clear segment may not exist within the network. The boundaries of the two sectors may be not as sharp as expected.

The hypothesis can be examined by identifying subgroups in the total network. A visualization of the network, showing how subgroups are related to each other in the network, is possible. The network structure can be visualized by making a 3D contour sociogram. As in the work of Moody (2004) local connectivity will be paired with higher density levels. A contour sociogram is based on density values present between closely connected actors. By using the bivariate distribution of points concentration of actors can be identified. Figure 3 presents the 3D contour sociogram for the principal component of the network. To get a clear insight only the main component (440 actors) instead of the total network (468 actors) was taken into account.

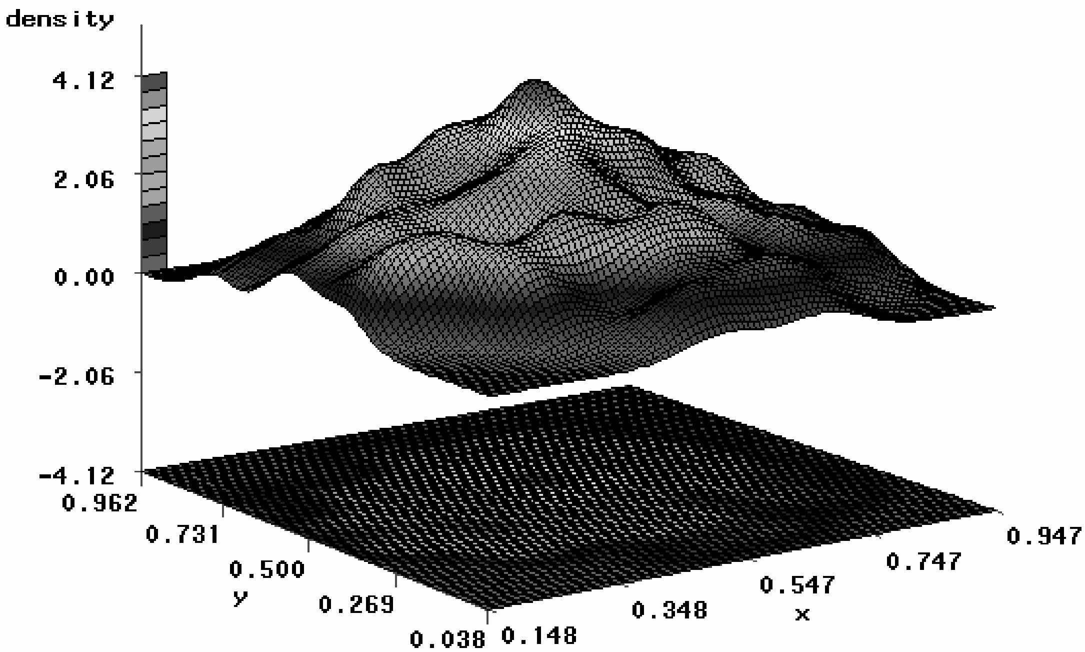

Figure 3. 3D contour sociogram of the SME network (principle component)[6]

The 3D contour sociogram shows a rather evenly spread network with one prominent hill[7]. This result indicates that the network between high-tech

[6] The 3D contour sociogram is based on the Kamada-Kawai layout of nodes. This layout considers the graph-theoretic path distance between nodes as a base for the geometric (Euclidean) distance (Kamada and Kawai, 1989).

[7] The lambda set approach can also be used to define the subgroups as in the work of Verspagen en Werker (2004). The approach looks at the whole network and focuses on the connections in the network, which, if removed, would result in a disconnected structure (Hanneman and Riddle, 2005). It shows the implication for the network from a macro-perspective. The identified sub-structures will have no overlap, in contrast of other concepts. Finally, lambda sets will identify sub-structures which have high connectivity between the members. To see if our results are robust, the lambda set approach was also performed for the network. The result was a single lambda set shrinking instead of multiple lambda sets emerging. In other words, the people who remain closely connected when more and more 'edge connections' in the network are being removed, take shape of a single group which becomes smaller and smaller. The presence of a single

industries and design contains one group of closely connected people. The question that remains is who are the key members in the core of this group? The next step is describing position of subgroups to the core of the field. The actual structure of subgroups will be discussed in more detail in the next paragraph.

Describing the network of Design and High-tech SMEs

We know something about the efficiency of the overall network, but can we also say something about which relations contribute to overall efficiency. We will have to examine what the origin is of those people that make up the closely connected group in the network. Since the people within the actual network can have activities in design as well as high-tech industries it is difficult to investigate the efforts into building bonding and bridging relations in relation to industry.

An alternative is to see if the origin of relations can be related to profit, non-profit and science domains. It would be interesting to know to what extend these labels are useful for describing the core of the emerging field, since these groups are focal point of EU and national knowledge stimulation programs (EC, 2006) [8]. Do the groups put in equal effort into building relations or are some groups more dominant than others in the closely connected group? Figure 4 presents the

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lambda set demonstrates that there are no clear boundaries between the design and high-tech industries. De results support the results of the 3D contour sociogram.

[8] Focal point is the Triple Helix of university–industry–government relations

composition, at various connectivity levels, of the network in terms of the division into profit, non-profit and science groups. This labeling was enabled by considering the organizations in which actors work.

The composition at density level 0 corresponds to the main component in total of the network. It can be observed that at this point the component consists approximately 70% of profit organizations. The other two groups measure 18% (non-profit) and 12% (science). This division remains rather constant for the lower density levels.

The interesting feature in figure 4 is the increasing role of non-profit and science-oriented persons in the evolving density levels. These results reveal the division present in the hill in figure 4. One may conclude from this that the more closely connected the actors get, the more prominent non-profit and science relations become. Among the most well connected people in the network are relatively more people who work for non-profit and science organizations. This prominent feature is interesting from a governmental point of view, trying to create a “triple helix” consisting of firms, governmental institutions and science organizations. The bias however seems to be too much towards non-profit and science organizations. More firm involvement might however be desirable.

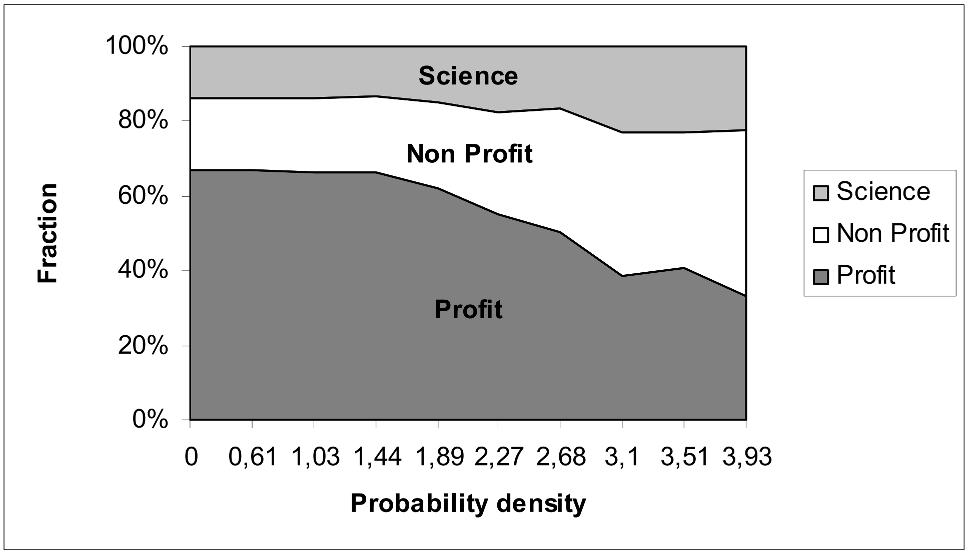

Figure 4. The evolution of the composition of sub-groups in the principal component

Conclusions and Discussion

This paper has undertaken the analysis of a SME network by making use of the theory of small worlds. It has argued that small worlds unify the best of two worlds; the theory of social capital (bonding capital) and the theory of structural holes (bridging capital). Both densely connected local environments and partnerships with interesting parts outside the local environment are needed to realize efficient knowledge flows. In a small world connectivity among local actors remains rather high; allowing the processing of complex information in the network. On the other hand 'average' path length is not very large; there is no impediment to the efficient spread of knowledge and information in the network.

Understanding characteristics of the network, the presence of bonding and bridging capital, will enable SME to use this knowledge to their own advantage.

The theory of small worlds provides a useful way of representing bonding and bridging capital. A single parameter shows, by measuring the number of ‘shortcuts’ in the network, local clustering and average path length. Subsequently the range of ‘small worlds’ as defined by Watts (1999) can be identified. When comparing the actual network between design and high-tech industries with the theoretical optimal configuration of Watts, the actual network can be classified as one in which a small world is present. Bonding and bridging capital are balanced in a more optimal way than in a random network. It can be concluded that this formerly invisible network is a relatively efficient means of knowledge transfer and exploitation.

Furthermore an in-depth look at the way bonding and bridging capital are balanced reveals that the field does not seem to be divided into multiple small worlds. The analysis focused on studying sub-communities and was operationalised by means of identification of cohesive subgroups at various levels of density. Visualization of the results shows a single core group in the network. This indicates that only a single densely connected group of people may be found in the field. The alternative would have been that the network breaks up into various sub-groups, embodying different sides in the industries, but this is not supported by the data. A further understanding of the characteristics of the network is enhanced by describing this core group of people. It was found that non-profit as well as science actors were overrepresented in the core of the field.

Together these results show structural characteristics of a SME network. Structural network characteristics provide background information on the current way of co-operating between organizations. The practical questions stated in the beginning of the paper: is knowledge transferred in an efficient way, are there partnership concentrations and who is involved in co-operations, have been answered. The results will be useful for regional politics to improve their interventions in the economic structure of the region. The questions are also interesting for SMEs, because it gives them an idea of where to turn to for knowledge in general.

Regarding the limitations of this study, we have little information on the representativeness of our sample for the total group of people involved in design and high-tech industries. A possible source of bias may be that the persons in the initial sample and first two waves have the advantage of being among the first mentioned. They have had more chance of being mentioned more often. Another possible source of bias is that the invitation to participate in the survey was signed by ourselves. Respondents might consider ourselves to be associated with a particular group, non-profit, and hence this may influence the willingness to participate in the survey. We have no opportunity to test the representativeness of the ‘invisible’ network sample against a more objective source of information. Therefore we can say little about the impact of this.

In policy terms this paper has brought about interesting findings. The triple helix between companies, governmental institutions and science organizations seems to be well present in this network. Despite the positive results, policy makers may reflect on these findings in terms of improving the efficiency of this network even more. In order to provide even more policy implications, future research might replicate this study for other SME networks in order to be better able to compare the relative efficiency of SME networks. Furthermore, future research might focus on performance differentials of different network structures.

Finally, the paper describes the core-group of people only to a certain extent. Known is how the network looks like and the origin of those who are relatively well-connected. Future studies could look at if specific parties make specific contributions to the efficiency of the network. Regarding our research we will investigate which parties play brokerage roles and what kind of brokerage roles. This will enhance our knowledge about the characteristics of brokers; those people who influence efficiency of networks.

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