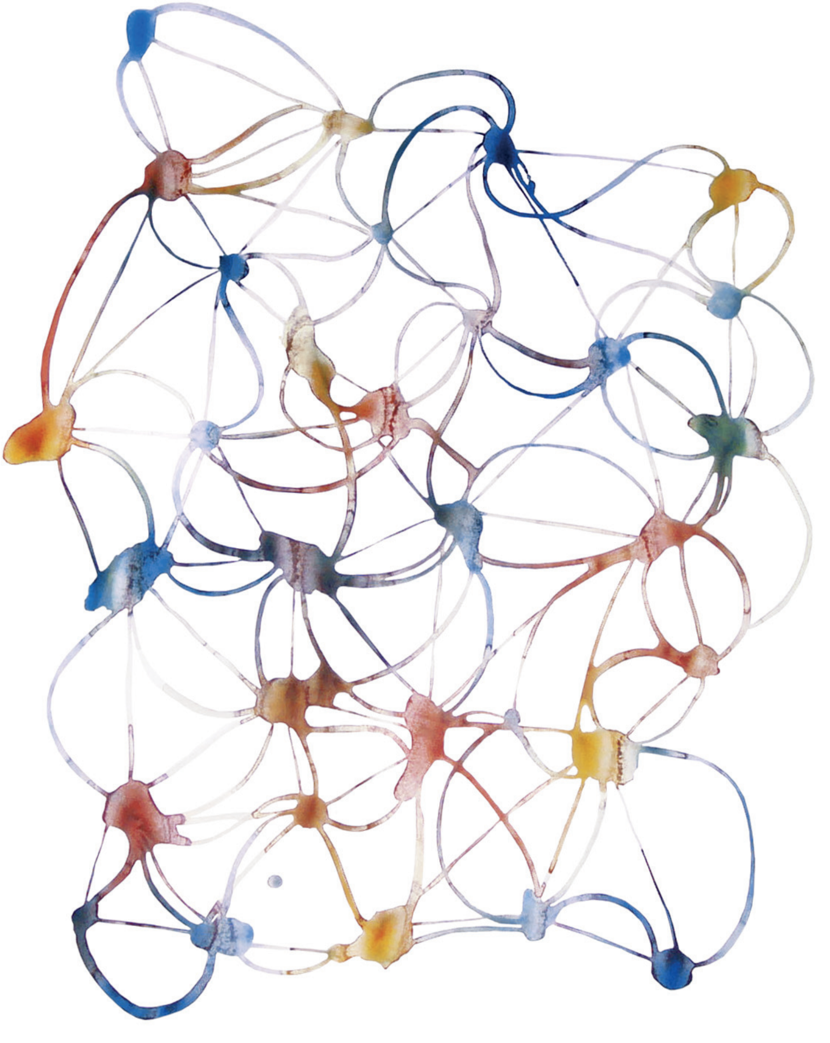
DIEDERIK W. VAN LIERE

Network Horizon and the Dynamics of Network Positions

A Multi-Method Multi-Level Longitudinal Study of Interfirm Networks



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Diederik Willem van Liere

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A Multi-Method Multi-Level Longitudinal Study of Interfirm Networks

Netwerk horizon en de dynamiek van netwerk posities
een multi methode multi niveau longitudinale studie van bedrijfsnetwerken

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Summary

The substantive purpose of this study is to address the dynamics of network positions in interfirm networks. While the benefits of network positions have received considerable attention in the interfirm network literature, the dynamics of network positions are less well understood. Network positions confer an advantage to a firm by providing access to valuable and scarce resources. The configuration of the set of interfirm relationships with other firms determines the network position that a firm occupies. Two well known and often studied network positions are the bridging position and the closed or dense position. A firm occupies a bridging position when its partner firms are not directly connected to each other, i.e. there are structural holes between the partner firms. By contrast, a firm occupies a closed position when its partner firms are directly connected to each other, i.e. there are no structural holes between the partner firms. The mechanisms by which these two types of network positions create value are orthogonal. The bridging firm creates value by exploiting information asymmetries between its partner firms such as information and control benefits while a firm occupying a closed position creates value by reducing information asymmetries and thereby creating effective sanction mechanisms, shared mental maps that facilitate knowledge transfer and effective reputation mechanisms. Changes in network positions, through establishing new or disbanding old ties, cascade through the network and may trigger counter partnering actions. These constant changes in relationships are the engine behind network position dynamics. Taking the bridging position as point of departure, this study investigates the strengthening, weakening and longevity of this position. We employ a multi-method, multi-level longitudinal research design using network experiments, computational modeling, and a field study.

Strengthening a bridging position requires information about the network structure in order to enable a firm to locate brokerage opportunities. The concept of *network horizon* is being introduced to define the degree of information which a firm holds on the structure of its interfirm network at a given point in time. Using network experiments and computational modeling, we demonstrate that firms which have a more

extended network horizon are better able to identify brokerage opportunities and hence capable of strengthening their bridging position. Furthermore, we find that there are diminishing returns to network horizon. It is not worthwhile to collect more information about the network structure after a certain level of information. However, not just the focal firm has a network horizon but the other firms in a network have this type of information as well although it is very likely that different firms have different types of information. Hence, we introduce a second concept called *network horizon heterogeneity*. Network horizon heterogeneity refers to the interfirm differences in the completeness of information about the network structure. We demonstrate, using a computational model, that network horizon heterogeneity is an important predictor of the sustainability of a bridging position. An interfirm network with a heterogeneous distribution of network horizon leads to less intense competition for bridging positions and hence a firm can benefit longer from such a position. In contrast, interfirm networks that are characterized by more homogenous distributions experience increased levels of competition for bridging positions and hence the sustainability of a bridging position is shortened.

Finally, we demonstrate, using network experiments and a field study, that resource similarity and resource dependence are important drivers of the dynamics of a bridging position. Resource similarity refers to the extent that partner firms have similar capabilities and resource dependence refers to how dependent one firm is on another firm. Both studies demonstrate that as resource similarity increases firms try to reduce the competitive pressure by establishing new interfirm relationships to reduce the competition between partner firms. The field study demonstrates that dependent firms strengthen their relationship with the firm that holds the bridging position, by severing interfirm relationships, and hence become even more dependent on the bridging firm.

Overall, this dissertation contributes to the interfirm network literature by offering insights why bridging positions strengthen, endure, and weaken. In summary, it is being proposed that the most valuable network positions are ones that will not last long. Such knowledge is important for both scholars and practitioners. Scholars may benefit from this study because it demonstrates why network positions change which is important to understand network-based competitive advantage. Practitioners may benefit from this study because it has provided important tools and methods for rigorous future research that will be highly relevant for managers to develop successful network strategies to win the best position in a networked world.

Acknowledgements

This dissertation is the product of a "network organization" in which I functioned as the "network orchestrator". As such, I am grateful to many people who have helped me during the last four years.

My Ph.D. would not have started if Lorike Hagdorn, my former master thesis supervisor, had not asked me, in the summer of 2002, to become a Ph.D. student on a project called "E-enabled Modular Business Networks". It did not take me long to say "yes" because it gave me the opportunity to pursue my passion for networks; it is a decision I have not regretted for a single day. I want to thank Lorike for asking me to become a PhD student and the feedback she has given me. During this period, Peter Vervest was the Chair of my dissertation committee. I am thankful for the fact that Peter has opened doors in the business world that have made it possible to write a dissertation that is both rigorous and relevant. Furthermore, Peter always challenged me to sharpen my thoughts and to think about the practical implications of the findings. One of my key responsibilities during the first two years was to develop the Business Network Engine. Martijn Hoogeweegen is the 'geestelijk vader' of this software project. I want to thank Martijn for helping me on the project management part and the feedback I received during those four years. Finally, I am very thankful to Otto. We have had countless discussions about ideas I had and Otto encouraged me to raise the bar. Those discussions have definitely improved the overall quality of the ideas presented in this dissertation.

As mentioned above, the first two years I acted as the software project manager of the Business Network Engine. I am very grateful to Ido de Lepper, Aldert Lamoré, and Dominique Campman (from BIT) for their support and commitment to this project. The development of the Business Network Engine and the field study would not have been possible without the generous support from ABZ, in particular from Gerrit Schipper, then CEO, and Herman Bennema, COO of ABZ. One of the initial goals of this research was to conduct network experiments using the Business Network Engine, not only with students but also with insurance brokers and managers from Delta Lloyd.

These were the so-called SIVI workshops. I am very grateful to Niek Hoek, chair and CEO of Delta Lloyd to see the potential of the Business Network Engine and to have his company adopt it in so many ways. This has definitely exceeded my expectations of the Business Network Engine. Furthermore, I want to thank Frank Elion, CEO of OHRA, and numerous employees for their support and help in organizing the SIVI workshops. I also would like to thank all the participants from Delta Lloyd and the numerous insurance broker firms for participating in this research. The SIVI workshops would not have worked out so well without the never-ending support from Frits Keij and Jeroen Tiekstra. Besides the network experiments with insurance brokers and managers, I also conducted experiments with students from the Business Network Student Team, thanks guys! I want to thank all my colleagues and the chair at the Department of Decision and Information Sciences for the great time I had during the last four years. Many of my colleagues participated in test sessions of the Business Network Engine during the first two years, thank you to everyone that helped improve the Business Network Engine. Jasper Voskuilen has been indispensable in programming the Large Interfirm NetworK Simulator (LINKS). The last part of this research consists of studying how insurance brokers change their network position in the real world. Jasper built the database and again his skills came in extremely useful.

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1 Why Does a Firm's Network Position Shift?

The world of businesses has become a dense interwoven web of relationships in which firms collaborate and compete simultaneously. Friedman (2005) calls it the "flat world", technological developments have erased the notion of geographic distance and have made it much easier to become part of this connected world. A number of trends have triggered the creation of the flat world. Among the more important trends are the increased interaction capabilities of companies (Chatterjee, Segars, & Watson, 2006; Holland & Lockett, 1997), lower communication costs (Butler et al., 1997) and the modularization of products (Hoogeweegen, 1997; Hoogeweegen, Teunissen, Vervest, & Wagenaar, 1999; Sanchez, 1995; Sanchez & Mahoney, 1996), processes and value chains (Wolters, 2002). The organizational capabilities to interact with and monitor other firms have been greatly improved because of modern information and communications technologies. Nowadays, a firm can maintain more relationships with more companies at much lower transaction costs than before. In addition, firms are increasingly focusing on a smaller part of the value chain and specializing their activities and thereby fueling the trend of flexible specialization (Piore & Sabel, 1984). The trends of specialization and focusing on core activities means that a firm needs an extensive network of suppliers to organize its production. Burt (2005: 2-3) describes the transformation as follows:

> *"Technology has expanded our ability to communicate across geographic and social distance. We removed layers of bureaucracy and laid in fast, flexible communication systems. Ask the leader of any large organization about the most difficult barriers he or she has to manage to harvest the coordination potential of our communication capabilities. They inevitable talk about people issues, culture issues. People continue to work the way they learned in legacy organizations, in yesterday's organization silos. We are capable of coordinating across scattered markets of human endeavor. We are not yet competent in how to take advantage of these capabilities."*

This study tries to narrow the gap, as noted by Burt, between, on the one hand, increased communication capabilities, and, on the other hand, our insufficient competence of taking advantage of these capabilities. One needs to understand dynamics of networks to do so.

1.1 Why Should We Study Network Position Dynamics?

The idea that firms are not self-contained autonomous entities but interdependent linked organizations has gained credibility in the field of business administration (Granovetter, 1985). Firms are increasingly part of one or multiple networks. These networks are so-called interfirm networks and are built around collaborations such as alliances, long-term buyer-supplier relationships, and joint ventures. Firms use their interfirm networks for different purposes, for example, to share resources, transfer knowledge, or minimize risk. We will focus on interfirm networks that jointly produce products.

Interfirm networks increase the interdependence between firms (Gulati & Gargiulo, 1999). Although these networks are probably more suitable to respond quicker to changing circumstances, the downside is that a firm has less discretion over the needed resources because it has become more dependent on its partner firms. This increased interdependence means that how a firm is embedded in the overall network structure, i.e. its network position, is becoming more important. The network position is important because it partly determines the access to resources (Gnyawali & Madhavan, 2001), information (Burt, 1992) and assets (Dyer, 1996).

Previous research on interfirm networks has predominantly focused on network effects rather than the dynamics of networks. How different network positions create different benefits and the contingencies of these benefits has been an important theme in the interfirm network literature (Ahuja, 2000a; Burt, 2000). In particular, the debate has revolved around the benefits of bridging and closed positions. A bridging position is one between two unconnected firms (i.e. a sparse position; a definition will be given in Chapter 2) while a closed network position is one in which the partner firms of a firm are also connected to each other (i.e. a dense position; a definition will be given in Chapter 2). However, the dynamics of network positions have received less attention. Do firms randomly obtain a beneficial network position or are there rational explanations why some firms have stronger network positions than other firms?

By network position dynamics, we refer to the changes in the position a firm occupies in the interfirm network. A network position is not a static given, rather it is the result of a firms' partnering decisions and the subsequent counter actions from the other firms in the network. Does a particular network position grow stronger over time or is it weakened by partner firm actions? What triggered these changes? Do we observe consistent patterns that predict these changes? Gulati, Nohria and Zaheer (2000: 210) observed that "the ties formed or disbanded by any actor influence not only their own behavior in subsequent periods but also those of others to whom the actor is connected. One actor forms an alliance. Others match this action." Networks are by definition relational, thus firms react to each other's actions, and hence the actions of one firm in the network have repercussions for other firms in the network. Changes in network positions, through establishing new or disbanding old ties, cascade through the network and can trigger partnering counter actions. A network position is dynamic, it is the cumulative result of partnering decisions through establishing and terminating ties by firms (Rowley & Baum, 2002).

These partnering decisions by the firm and its competitors have both intended and unintended consequences for the attractiveness of a network position. These constant changes in benefits received from a network position are the engine behind network position dynamics. Madhavan, Koka & Prescott (1998: 440) put it as follows: "We take the position that managerial action can potentially shape networks so as to provide a favorable context for future action. In order to understand how managers may do this, research needs to move beyond asking how networks constrain and shape action, to examining what factors constrain and shape networks." Thus, the partnering decisions of firms shape the network position of a firm and this position has repercussions for future partnering decisions.

Firms establish interfirm linkages to gain access to knowledge (Powell, Koput, & Smith-Doerr, 1996), learn new skills (Baum, Calabrese, & Silverman, 2000), acquire new technologies (Stuart, 1998) or manage their interdependencies (Pfeffer & Salancik, 1978). These interfirm relationships aim at creating a better fit between the firm and its environment. The fit between firm and environment will weaken as either the environment or the firm changes. These changes are the reason for a firm to adjust its portfolio of interfirm relationships and hence it will change its network position. As networks become ubiquitous and more important (as we will argue in Chapter 2) so will the network position of a firm become more important. Adding a dynamic perspective on network positions increases our understanding of how particular network positions evolve, why some firms benefit longer from their network position than other firms do and how interfirm networks emerge and evolve over time. In addition, understanding the dynamics of a network position helps developing a network strategy (Rowley & Baum, 2002; Shipilov, 2006). A network strategy guides a firm in partner selection, shifting its network position if necessary and turning the network position into a valuable resource. Therefore, it is important to understand the mechanisms that are responsible for a firm to change its network position.

1.2 Overall Research Question and Theoretical Issues Addressed

This dissertation raises the following overall research question:

> "*Why does the network position of a firm change?*
> *Which firm, partner firm, and network factors accelerate or slow down this change process?*"

There are many different network positions in an interfirm network but a particular important type of network position is the bridging position. This type of position has been often associated with above average performance of both firms and individuals (Burt, 2000). However, the process by which firms come to occupy this position is less well understood (Salancik, 1995). Because a bridging position is an important way to create value (Burt, 2000), it is important to understand why such positions become stronger, why these positions last and finally why these positions weaken or even disappear. Salancik (1995) even argued that the field of network research should move beyond questions about the effects of network positions and raise questions that focus on why particular positions exist or do not exist in the first place. Salancik (1995: 349) phrased it as follows: "a more telling analysis might explain why the hole exists or why it was not filled before."

We will draw heavily from three streams of literature to answer the overall research question. The first stream of literature is structural hole theory (Burt, 1992; Burt, 2000), the second stream of literature is resource dependence theory (Pfeffer & Salancik, 1978) and the third stream is the information processing view of the firm (Daft & Weick, 1984). The first issue we will explore is the effect of having information about the network structure to strengthen a firm's bridging position. Before a firm can initiate or respond to a change in the network position by its competitors (through a new partnering decision), a firm has to be aware of such actions and their effects. This requires information about who, how and when the interfirm network changes. Acquiring information about the network structure is the first step for a firm to shift its network position. An important but not often researched assumption in much of the research about interfirm networks is to what extent a firm has information about the overall network. Rowley and Baum (2004: 120) phrase it as follows: "The idea that managers are aware of their firms' networks and the types of positions that provide social capital advantages – core assumptions underpinning the network strategy perspective – remains largely unexplored". Firms that are unaware of the overall pattern of the network structure will not be aware of all the opportunities for establishing new ties and thereby strengthening their bridging position.

The second issue we will explore is how information about the network structure enables a firm to shift its network position. Periods of network position changes and relative stability succeed each other (Kilduff, Tsai, & Hanke, 2006). The relative information advantage or disadvantage a firm has partly determines the competition for a network position. Networks that are characterized by firms that have extensive information about new opportunities are more likely to compete for such positions than networks with firms that have a limited view of the network. This is an important issue because recent research suggests that some network positions are not sustainable (Burt, 2002). If this is the case, then firms who have a strong network position cannot rest on their laurels while firms with a weak network position already have the incentive to strengthen it.

The third and final issue we will explore is that the actions of partner firms may weaken the bridging position of the focal firm. A bridged firm (i.e. the firm that is connected through the bridging firm to a third firm) is being exploited in such a situation. This gives the bridged firm the incentive to end this situation and to weaken the bridging position of the focal firm. We adopt a resource dependence view (Pfeffer & Salancik, 1978) and investigate how resource dependence and resource similarity provide the bridged firm the incentive to establish new interfirm relationships and thereby weakening the bridging position of the focal firm.

1.3 Contribution of the Dissertation

This dissertation contributes to two bodies of literature. First, we advance structural hole theory by adding a dynamic perspective. In particular, we formulate an information-based theory of the rise and demise of the bridging position of a firm. This is an important contribution because it increases our understanding of the dynamics of network positions, which is important because firms will have a greater understanding of how to shift their network position in a way that is beneficial for them. We will demonstrate that if a firm aims at strengthening its bridging position, it will need to have information about the network structure to detect brokerage opportunities. Subsequently, we will demonstrate that the relative advantage a firm has in terms of having more complete information about the network structure partly determines how long a firm benefits from its bridging position.

Second, we advance resource dependence theory and demonstrate that resource dependence is not just an important network formation driver (Gulati & Gargiulo, 1999) but also an important driver for a firm to change its network position. More specifically, when a firm becomes dependent on a partner firm then it is more likely to restructure this dependence by forging closer bonds with the bridging firm. This means that the bridging position of the focal firm strengthens due to the partnering decisions of its partner firms. Furthermore, we demonstrate that high levels of resource similarity (i.e. firms possess the same set of capabilities) lead to increased competition and this triggers a firm to shift its network position as well. These three factors combined, information about the network structure, resource dependence and resource similarity, form the basis of a model of the dynamics of network positions.

1.4 Managerial Relevance

Increased specialization and developments of information and communication technologies (ICT) have facilitated the growth of interfirm networks (as we will discuss in Chapter 2). For example, the number of firms and links on the Internet today are a multifold of what it was 10 years ago (Kotha, 1998). The simultaneous growth of the Internet and the increased interdependence of firms due to developments in ICT make the position a firm occupies in a network an increasingly important resource to pay attention for decision-makers. As the size of the Internet increases, it is more important for firms to know what position they hold - or should hold - in the network. Closely coupled to the position a firm currently holds, a firm should also understand how the network develops in order to take a position that is most favorable for its performance[1].

Managing a firm's network position is becoming a concern for firms that are increasingly involved in buyer – supplier relationships, alliances and other forms of interorganizational contracts, such as licensing and joint ventures; it becomes more and more important for organizational decision-makers to understand the factors that determine the dynamics of a network position. The reason for this is that the network position of a firm is an important determinant of firm performance such as degree of innovativeness (Powell et al., 1996), firm growth (Powell, Koput, Owen-Smith, & Smith-Doerr, 1999), and financial performance (Baum, van Liere, & Rowley, 2006). The consequences of a partnering decision become clearer to organizational decision-makers as they understand the mechanisms that explain why a network position changes. Knowledge about the mechanisms of network position dynamics is a prerequisite for sensible managerial network action.

Finally, organizational decision-makers can improve the quality of their network actions by devising a network strategy. Such a strategy can become an important component of a supplier or partner selection process. Future suppliers are not just selected based on their qualities, but the impact on establishing a relationship with this supplier is also assessed. How does the network position of the firm shift when this relationship is established? Furthermore, it guides a firm in selecting whom to monitor and how to maximize the benefits of the current network position.

1.5 Research Design: a Multi-Method Multi-Level Longitudinal Approach

We adopt a multi-method (Brewer & Hunter, 1989) multi-level longitudinal approach for investigating firm, partner-firm, and network factors that influence network position dynamics. Studying the dynamics of network positions implies that network positions change. A longitudinal approach is required to observe and study such changes. Hence, without longitudinal data it will not be possible to address our overall research question.

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[1] Performance of a firm in a network can be measured at both the firm and network level (Straub, Rai, & Klein, 2004). In this study, we will explicitly focus on performance at the firm level. We do recognize the potential of studying network performance but we address this topic in the future research section of Chapter 7.

Mingers (2001) advocates a multi-method approach for five reasons:

1. A multi-method approach is an effective way of dealing with the full richness of the phenomena studied.
2. A study is rarely a single event but often a longer process and different methods may yield different insights during the study of the whole process.
3. Validating data using triangulation increases the internal and external validity of the research.
4. A multi-method approach encourages creativity of the researcher by "discovering fresh or paradoxical factors that stimulate further work" (2001: 244).
5. A multi-method approach possibly increases the generalizability of the research.

These reasons are compelling, and therefore we choose to adopt a multi-method methodology for this dissertation. Triangulation is a technique to increase the validity, both internal and external, of the research by using different data sources, measurements or methods (Scandura & Williams, 2000) to study the same research topic. We adopt a method triangulation approach. Method triangulation is the process of using different research methods to study the same phenomenon. The three methods we will use are network experiments, computational modeling, and a field study. Each research method has its strengths and weaknesses.

The advantage of experiments and simulations is that both methods create a tightly controlled environment that allows a researcher to establish causality and increase the internal validity (Shadish, Cook, & Campbell, 2002). Field data have the strength of high external validity. Combining these three methods should lead to robust conclusions about the dynamics of network positions compared with a single method study. McGrath (1982) identifies three dimensions to rate a research method: these are generalizability of the results, precision of measurement and realism of context. Table 1-1 shows how our three methods score on each of these three dimensions (Scandura & Williams, 2000).

	Network experiments	**Computational modeling**	**Field study**
External validity	Low	Low	High
Precision of measurement	High	High	Low
Realism of context	Low	Low	High

Table 1-1 Strengths and weaknesses of different research methods

Our triangulation of research methods enables us to score high on each of the three dimensions of a research design. Furthermore, we respond to the call to use triangulation by Scandura et al. (2000) who note a drop of the use of triangulation in management research that potentially can impede internal, external and construct validity.

Replicating the same study using a different research method challenges the researcher to assess whether the operationalizations made in one study can be replicated or should be refined to accommodate this new setting while staying consistent with the previous study. Refining the operationalizations gives more insight about how a particular construct operates but this asks for creativity. Finally, generalizability is important because it reflects for a large part the benefits of this research to managers and decision-makers. By combining analysis from different research methods, we aim at giving a fuller and richer understanding of network position dynamics that in turn will help organizational decision-makers in formulating a network strategy.

Interfirm networks are inherently multi-level, firm behavior affects the network structure and the network structure gives a firm opportunities and constraints and this influences firm behavior. Scholars have often argued that network researchers should adopt a multi-level approach (Moldoveanu, Baum, & Rowley, 2003). One of the key strengths of network research is that it is multi-level where independently or simultaneously firm level, relationship level, and network level analyses can be conducted (Contractor, Wasserman, & Faust, 2006). A multi-level approach aims at explaining macro level outcomes using micro level inputs or vice versa. Madhavan (2003) stresses the importance of multi-level network research by stating "What could be a more inherently multi-level phenomenon, and in greater need of multi-level conceptual frameworks and empirical strategies, than the evolution of networks?"

Applying a multi-level approach to this dissertation means that we incorporate focal firm, partner firm, and network level variables to account for changes of the network position of the focal firm.

1.6 Structure of the Dissertation

After this introductory chapter, Chapter 2 provides a review of the antecedents, performance implications and processes of network positions and in particular reviews the bridging and closed network positions. This chapter finishes with three detailed research questions that will be the focus of the empirical chapters. Chapter 3 introduces three research methods and describes the data that we will use for conducting our research. Then, three empirical chapters are presented (Chapter 4, Chapter 5, and Chapter 6). These chapters are relatively independent of each other: each chapter addresses one specific research question but the three chapters jointly cover the whole life cycle of a bridging position. Finally, in Chapter 7 we draw our conclusions; discuss the generalizability of the studies, highlight the managerial relevance and discuss implications for future research. Figure 1-1 illustrates the structure of the dissertation.

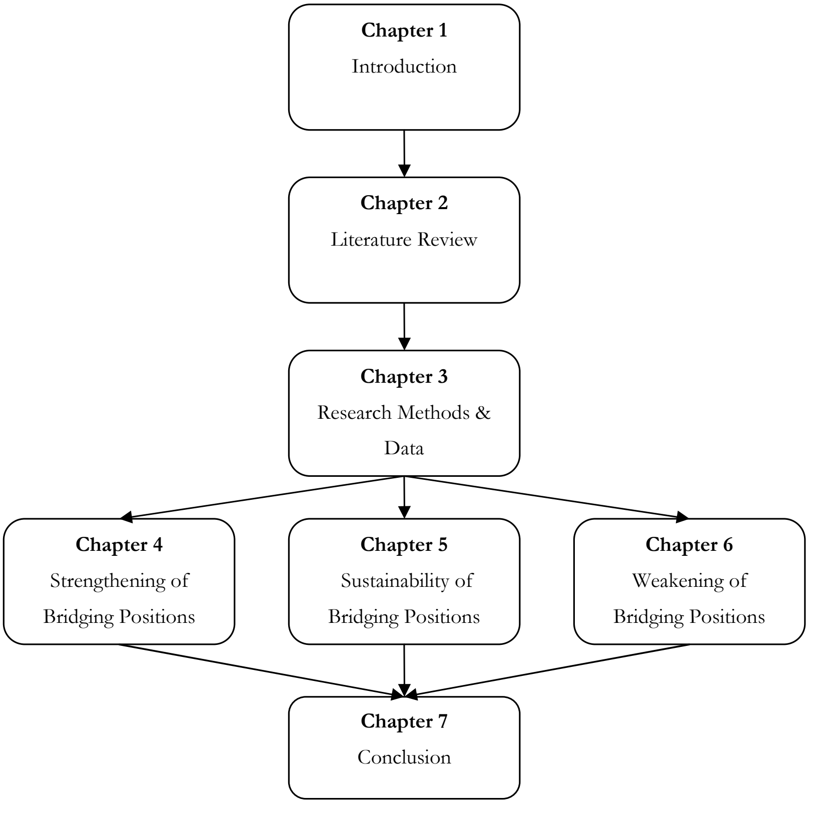

Figure 1-1 Structure of the dissertation

We will now proceed with reviewing the literature on the origins, benefits, and dynamics on network positions.

2 Network Positions: Origins, Performance, and Dynamics

This chapter will review current knowledge about network positions in order to develop the detailed research questions concerning the dynamics of network positions. Before we discuss the dynamics of network positions, we will first describe why firms are embedded in an interfirm network in the first place and hence why a network perspective is essential for understanding firm behavior. Firms enter, increasingly, alliances and long-term buyer supplier relationships or more informal collaborations (Gomes-Casseres, 1996; Granovetter, 1985; Gulati & Gargiulo, 1999). The collection of such interfirm relationships creates an interfirm, or business network. This interfirm network is an important determinant for access to valuable resources and information (Baum et al., 2000; Burt, 1992; Gnyawali & Madhavan, 2001). Furthermore, we highlight several recent developments that increase the salience of the network perspective. Section 2.1 highlights the growing importance of interfirm networks and identifies two important drivers for an increasing use of interfirm networks: communication and information technology and the increased specialization of firms. These two developments are important antecedents of interfirm network formation.

Having established the growing importance of the interfirm network, we then focus on how particular network positions in these interfirm networks impact a firm's performance in Section 2.2. The position in the network can have a significant impact on firm performance and is an important source of competitive advantage (Dyer & Singh, 1998; Gnyawali & Madhavan, 2001; Podolny, 1993; Powell et al., 1999; van Heck & Vervest, 2007; Vervest, van Heck, Preiss, & Pau, 2005). We will argue that some positions are more beneficial than other positions. Especially "bridging" (Burt, 1992) and "closed" (Coleman, 1988) network positions have often been linked to the improvement of firm performance. These two network positions are critical to this study as they define two extreme positions in terms of structure and value creation. If some positions are more beneficial than other positions then firms will try to improve their current position in order to reap more benefits. Thus, beneficial network positions contain the seeds of network position dynamics because firms are triggered to improve their own position. And indeed as Sorensen and Ryall (2007) have shown a network position can be a source of competitive advantage but it is rarely a source of *sustainable* competitive advantage. Therefore, in Section 2.3 of this literature review, we will focus on the current knowledge of network position dynamics. This section analyzes how network positions change over time both from the perspective of the networks and from the perspective of the firm. Drivers for change as well as stability ("network inertia") are identified. The final Section 2.4 develops three detailed research questions subject for detailed research in Chapters 4, 5 and 6 respectively. These three detailed research questions focus on why bridging positions become stronger, why some positions last longer, and why bridging positions become weaker.

2.1 What Drives the Development of Interfirm Networks?

This section is devoted to highlight some important factors that drive the development of interfirm networks. We will focus on three important factors: resource interdependence (Gulati & Gargiulo, 1999; Moldoveanu et al., 2003), increased specialization of firms, and developments in information and communication technology. Before we continue with this discussion, we first define an interfirm network used on Podolny and Page (1998: 59).

> **Definition 1: interfirm network:** "a collection of firms (N≥2) that pursue repeated, enduring exchange relations with one another and, at the same time, lack a legitimate organizational authority to arbitrate and resolve disputes that may arise during the exchange"[2].

This definition excludes exchange networks within large firms, transaction networks that are governed by spot markets, transactions conducted through (reverse) auctions, non-repeated transactions, or other transactions that are minimally embedded in a social relationship. The following section introduces resource dependence theory (Pfeffer & Salancik, 1978) as the first important driver of interfirm network formation.

[2] A definition between quotation marks ("") is a literal definition taken from the mentioned source while a definition without quotation marks is self-constructed.

2.1.1 Interdependence as driver of interfirm networks

Pfeffer and Salancik have been among the first to make a convincing case in *The External Control of Organizations* that firms are embedded in - and therefore dependent on - interfirm networks (Pfeffer and Salancik, 1978). Their resource dependence theory assumes that all firms are, to a varying extent, dependent on their environment for survival: This environment contains valuable and scarce resources that the firm needs but does not possess. Pfeffer and Salancik (1978: 40) define interdependence as follows:

> **Definition 2: interdependence:** "a firm does not entirely control all of the conditions necessary for the achievement of an action or for obtaining the outcome desired from the action".

The level of interdependence between two firms depends on two factors: how important a resource is for a firm (resource importance) and who controls the resource (resource discretion) (Pfeffer & Salancik, 1978). For example, a critical resource owned by a partner makes a firm highly dependent on this partner. Especially when the reverse is not true, (i.e. the partner is not dependent on that firm).

There are two effects of interdependence: first, the dependent firm becomes more uncertain about (access to) the resources it needs because they are under external control and therefore more difficult to manage and their availability more difficult to forecast and to control. Second, the firm with discretionary control over the resource becomes more powerful as it can dictate the terms of the exchange for these resources. Such differences in power become even more problematic in the case of *asymmetric* resource dependence between two firms. For example, Firm A is more dependent on firm B than firm B is on firm A.

Symmetric interdependence balances the power of both firms. Asymmetric interdependence reduces the ability of the powerless firm to manage its external resources and thereby increases its uncertainty. This difference in power constrains the powerless firm in the actions it can take.

Resource importance, uncertainty, and imbalance of power are motives to (try to) restructure the interdependence. A firm can change its dependence through unilateral or bilateral / multi-lateral actions. Examples of unilateral dependence restructuring are efforts to engage new relationships for alternative sources of supply, to form coalitions or to reduce the need for a particularly valued resource (Casciaro & Piskorski, 2005).

Examples of bilateral dependence restructuring are cooptation (the process of socializing members of the constraining partner firm, for example to offer them a seat on the board of the firm) or joint reduction of dependence by mutual exchange of valuable resources (Casciaro & Piskorski, 2005). In this study, we will focus exclusively on the unilateral restructuring of resource dependencies. These unilateral changes, like finding an alternative supplier of a resource, are the engine of network position dynamics. Unilateral restructuring of resource dependencies imply a shift in a firm's network position, while a bilateral restructuring of resource dependence suggests a change in the governance of the relationship but it does not imply a change in a firm's network position.

The existence and the restructuring actions of interdependence are important drivers to establish interfirm networks: it is a way to reduce uncertainty that stems from the dependence; and to counter balance differences in power according to Gulati & Gargiulo (1999).

2.1.2 Increased specialization as driver of increased use of interfirm networks

The previous section introduced the notion of interdependence; this section argues that interdependence between firms is increasing because of two important developments: 1) *focus on core capabilities a*nd 2) *dissection of the value chain*. We will address both developments in this section.

First, increased specialization allows a firm to improve its performance by focusing on core capabilities (Prahalad and Hamel refer to "core competencies"), while still being able to compose complete products via linking in the value chain (Brusoni, 2005; Jacobides, 2005; Jacobides & Billinger, 2006). 'Stick to your knitting' has become a dominant managerial theme and has led to a steady demise of vertical integrated and diversified companies. Focusing on core capabilities (Prahalad & Hamel, 1990) has propelled firms to downsize and outsource activities that are not on par with a firm's competitors. Amit and Schoemaker (1993: 35) define a capability and resources as

Definition 3: capability: "a firm's capacity to deploy resources, usually in combination, using organizational processes, to effect a desired end".

Definition 4: resources: "as stocks of available factors that are owned or controlled by the firm".

A firm that increasingly specializes on a limited part of the value chain will become increasingly interdependent on other firms: It will control a narrower set of resources itself and will become more dependent on resources under external control. While a focus on core capabilities may have made companies leaner, it also means that network partners becoming increasingly important because firms do not have the required resources and capabilities for internal production themselves.

Second, firms are increasingly specializing their core capabilities and relying on their network of firms to complement their own core capabilities. This process leads to vertical disintegration: the value chain transforms from an integrated value chain towards a modular value network. Two processes fuel this process of vertical disintegration: intrafirm specialization and interfirm co-specialization (Jacobides, 2005). Intrafirm specialization is the process by which firms focus on a small part of the value chain, organize themselves as autonomous sub-units and source to both internal and external customers (Jacobides, 2005). An example of this process is the increased use of shared service-centers that provide services to different units from the same firm as well as to other, sometimes competing, firms. A consequence of specializing on a particular set of components is that it becomes inevitable that a firm becomes more dependent on other firms for the required components. Interfirm co-specialization is the process by which firms learn and mutually adjust to each others offerings and devise institutions for effective exchanges (Jacobides, 2005). As firms continue their specialization, they find themselves more apt at their role in the value chain. Adaptation between two firms takes place to maintain the integrity and functionality of the product because of continued innovation: the result of this adaptation is that firms find "mutually complementary roles" (Jacobides, 2005: 484). Thus, firms are increasingly embedded in a network of firms because the number of firms to collaborate increases as the dissection of the value chain progresses.

2.1.3 Technology as driver of increased use of interfirm networks

A second important driver for increased use of interfirm networks is the rapid development of information and communications technology (ICT). These developments have made it easier and more efficient to use interfirm networks for the production of services or goods in three ways: 1) a reduction of interaction costs (Butler et al., 1997); 2) creation of "quick connect capabilities" (Sanchez & Mahoney, 1996) of actors in the value chain; and 3) the increasing use of modular product architectures (Sanchez, 1995) as a way to compose and orchestrate distributed production processes.

First, there is consensus among scholars that communication technology lowers interaction costs both within the firm as between firms (Hitt, 1999; Malone, Yates, & Benjamin, 1987) and this leads to lower coordination costs. This reduction of interaction costs is due to standardization of communication (Butler et al., 1997). The Internet has made an important contribution to standardized communication: a firm can now maintain more relationships with fewer resources than ever before. Reduced interaction costs make it possible to embed electronic relations within social relations and make efficiency gains in maintaining these social relations. Communication and information technology have been more often associated with increases in efficiency. For example, Brynjolfsson et al. (1994) study of the impact of IT on firm size shows that firm size decreases when firms invest in IT. Thus, increased efficiency makes extra resources available to initiate new relationships and thereby making the interfirm network more important. Summarizing, a reduction of interaction costs makes it cheaper to maintain interfirm relationships.

Second, the ability of a firm to use information and communication technology to form interorganizational links is becoming a distinctive capability (Chatterjee et al., 2006; van Liere, Hagdorn, Hoogeweegen, & Vervest, 2004; van Liere, Hoogeweegen, Hagdorn, & Vervest, 2006; Vervest, Preiss, van Heck, & Pau, 2004). We refer to this capability as the "quick-connect capability". A "quick"-connect capability consists of the knowledge, standards and information technology to establish an interfirm relationship (Sanchez & Mahoney, 1996) in a very short time frame, i.e. without the usually cumbersome coordination of processes between different actors. Standardization of interfirm communication is an important prerequisite for a quick connect capability (van Liere et al., 2004). A quick connect capability consists of two aspects: 1) there is a technological infrastructure that facilitates the communication of the exchange of information and transactions and 2) there is an interorganizational systems (IOS) link that connects the two firms. Creating such a technological infrastructure and IOS links is a difficult process of mutual adaptation, making IT systems compatible and standardizing communication. While the initial development costs of such a technological infrastructure may be quite high, the benefits will increase as more firms adopt a quick connect capability. There are network externalities (Katz & Shapiro, 1986; Riggins, Kriebel, & Mukhopadhyay, 1994) in the adoption and diffusion of a quick connect capability. The benefits of a quick connect capability (such as reduction of errors, increased efficiency through the elimination of re-entering data) are more often realized as more firms participate. Once a quick connect capability has been established it can be instantaneously activated. The net effect of standardization of communication and adopting quick connect capabilities is that the cost to maintain ties are lowered. Alternatively, for the same amount of resources more relationships can be sustained. Consequently, a firm can expand its network range (Reagans & McEvily, 2003) (its diversity of resources, assets, and information) by establishing new ties. Summarizing, quick connect capabilities make it easier to establish interfirm relationships.

Third, modularization of products leads to an increased use of interfirm networks (Langlois & Robertson, 1992; Schilling, 2000; Schilling & Steensma, 2001; Sturgeon, 2002). Modularization is breaking down a product in core blocks of functionality. Modular components do not have to be produced by a single firm but can be made by a network of firms. Schilling and Steensma (2001: 1151) define modularity as:

> **Definition 5: modularity:** "components can be disaggregated and recombined into new configurations – possibly with new components – with little loss of functionality".

Thus, modularity allows components to be produced separately and used interchangeably in different configurations without compromising system integrity. This allows for mixing and matching of components to create customized products. The design and production of modular products does not happen sequentially but rather concurrently and autonomously (Sanchez, 1995), possibly within a network of firms. The first consequence of adopting a modular product architecture is that it becomes possible for a firm to decide at a finer level of detail which components of a product it will produce itself and which components it will procure. Once a firm adopts a modular product architecture it can adjust its firm to mirror the creation and production of these components. Modularization of products increases the options to ally with other firms (Jacobides & Billinger, 2006). Furthermore, modularization does not only happen at the product level but also at the process and value chain level (Wolters, 2002). Therefore, the number of firms to choose from with whom to collaborate increases as modularization becomes increasingly more important (Brusoni, 2005). Summarizing, a firm will have a more diverse set of firms to choose from when these firms modularize their products and processes.

2.1.4 Summary: interfirm networks are driven by specialization and technology

Thus far, we have been arguing that the emergence of interfirm networks is the result from increasing interdependencies between firms through specialization of firms within the value chain (Jacobides, 2005; Jacobides & Billinger, 2006) and the adoption of new technologies. Figure 2-1 summarizes the technological and specialization developments and illustrates how these developments have increased the use of interfirm networks. Both technology and specialization lead to an increased interdependence between firms. Firms use interfirm networks to manage the increased dependence.

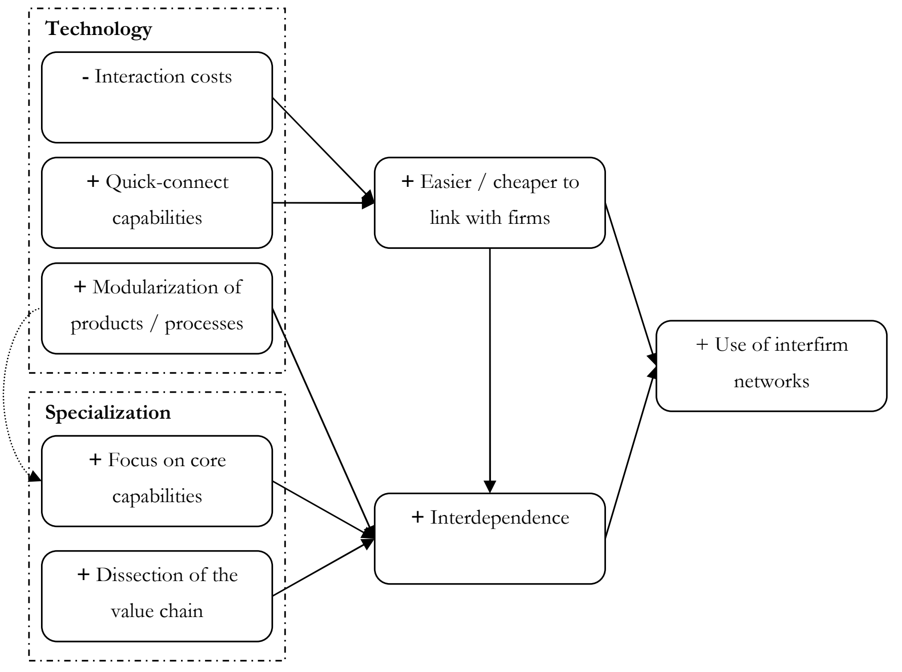

Figure 2-1 How technology and specialization drive the use of interfirm networks

2.2 Why Bridging and Closed Positions Increase Firm Performance

The interfirm network literature distinguishes different types of network positions. The most important network positions are the bridging or structural hole position and the embedded or closure position. A firm occupies a “bridging position” when other firms must pass through this firm in order to reach each other. A dense or “closed position” is characterized by the existence of many alternative links to firms in the ego network. However, in order to understand the antecedents, effects, and processes of these two positions, we first need to introduce some basic terminology that underlies the structural embeddedness perspective that we use to study the relationship between network position and firm performance[3,4].

2.2.1 Introduction: structural embeddedness of network positions

Organizational and IS scholars are increasingly emphasizing the importance of interfirm relationships as a valuable source of firm performance and competitive advantage (Barrett & Konsynski, 1982; Burt, 1992; 2000; 2005; Coleman, 1988; Koka & Prescott, 2002; Lin, 1999; Malhotra, Gosain, & El Sawy, 2005; Straub et al., 2004). The collection of interfirm relationships that a firm maintains is often referred to as a firm’s social capital (Maurer & Ebers, 2006). Nahapiet and Ghoshal (1998: 243) define social capital as:

> **Definition 6: social capital:** “the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit”.

The way a firm is embedded in the overall network of interfirm relationships, (i.e. network structure), determines its access, both realized and potential, to other resources.

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[3] How well a firm operates in a network can be measured at both the firm and network level. However, we focus in this study exclusively on performance measured at the firm level because a firm is not concerned with network performance as long as its own performance is consistent with its competitors or meets its aspiration level. Furthermore, none of the firms in a network is responsible for network performance; creating a bigger pie (i.e. increasing the network performance) is not a major concern if a firm cannot claim the additional created value (i.e. how is the pie going to be split). Finally, measuring network performance is an area of research in its infancy stage that makes it harder to operationalize.

[4] Although firm performance will not be an outcome we will directly study in the empirical chapters, it refers to ‘how well’ a firm is functioning. Often used measures include financial metrics such as return on income, return on assets, margin or market share; non-financial measures include patent count or more context specific metrics. See also Table 2-1 for an overview of firm performance indicators.

Nahapiet and Ghoshal (1998) distinguish three types of embeddedness of social capital: structural, relational and cognitive. Structural embeddedness refers to the quantity (direct and indirect relationships) and pattern of interfirm relationships (Granovetter, 1992). This perspective emphasizes how the structure of these relationships determines access to other firms in the network. The absence or existence of a relationship is important from a structural embeddedness perspective (Wasserman & Faust, 1994). Relational embeddedness refers to the quality of interfirm relationships (Granovetter, 1992). In this perspective, the focus is on what actually flows through a relationship rather than the existence or absence of a relationship. Relational embeddedness focuses on trust, norms, frequency of interaction, and the type of information and resources exchanged. Cognitive embeddedness refers to the shared understanding, meaning, and interpretation that actors give to their environment. Cognitive embeddedness is a consequence of relational and structural embeddedness and is important because it focuses attention on specific events in the environment, gives meaning to clues and interprets information that is acquired from the environment (Baum, Shipilov, & Rowley, 2003). Although these three types of embeddedness are conceptually distinct, in practice they are interrelated.

For the purpose of this study, the structural embeddedness perspective seems appropriate because network position is a structural dimension of networks. The structural embeddedness perspective belongs to social network analysis and focuses on the quantity and overall connections between firms but does not take into consideration the contents of relationships. The consequences of this limitation are that we do not 'open' an interfirm relationship to study the actual contents of interfirm resource flows, nor do we investigate how an interfirm relationship is managed. Throughout this study, we will use some basic network terms, this section offers a starting vocabulary.

Definition 7: focal firm: the firm[5] being analyzed.

Definition 8: relationship: is a recurrent connection between two firms that can be used to transfer both tangible and intangible resources such as assets, knowledge, money, and information. Such a relationship can be managed by

[5]A firm that belongs to an interfirm network is also sometimes referred to as "party", "actor", or "node".

either formal or informal agreements[6]. Relationships are also referred to as "links" or "ties".

Definition 9: alter firm: a firm with which the focal firm (definition 7) has a direct relationship. We will use alter firm and partner firm interchangeably.

Definition 10: ego network: the network consisting of the focal firm and its partner firms, the relationships between the focal and the alter firms (definition 9) and relationships among the alter firms themselves.

An indirect link means that two firms do not hold a direct relationship (a direct link without a passing node in-between) but have access to each other via other firms. We define "network structure" as follows (based on Wasserman & Faust, 1994: 20):

Definition 11: network structure: the collection of actors and their relationships (definition 8) at any given point in time.

The definition of network position is based on Burt (1980: 893):

Definition 12: network position: the pattern of relations to and from an actor within a network structure (definition 11).

The configuration of a firm's interfirm relationship portfolio (i.e. how and to whom it is connected) determines its network position. The collection of network positions of the firms that constitute a network determines the network structure. The network position and the network structure determine the length of a path to other member firms, or nodes, of the network.

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[6] Our definition of relationship excludes personal relationships between individuals from different companies. Even though such relationships are used to exchange resources such as information, in an informal way, between companies and such relationships can be recurring, we do not consider these as an interfirm relationship. The reason is that the motive to establish this relationship was a personal one between two individuals. However, in theory, such a personal informal relationship can evolve into an interfirm relationship if there are appropriate business motives to do so.

This study restricts itself to discussing how bridging and closed network positions improve firm performance. Obviously, there are more types of network positions. Examples include the central position (Powell et al., 1996), a firm can quickly reach any firm in the network compared to a peripheral firm; the peripheral position (Borgatti & Everett, 1999), a firm has a high average distance to any other firm in the network; and, the structural equivalent position (Walker, Kogut, & Shan, 1997), a firm has a set of common relationships to other firms in the network. However, these positions are not grounded in a theory to explain why and when they matter for firm performance; therefore, these positions are outside the scope of this study. The implication of this restriction is that our findings may not generalize beyond the bridging position but we will address this issue in Chapter 7. In the next section we will show how bridging positions increase firm performance.

2.2.2 How bridging positions increase firm performance

One of the most frequently used theoretical lenses to explain firm performance from a network perspective is structural hole theory (Burt, 1992). Burt (1992) argues that a firm that has non-redundant ties will create information and control benefits. A non-redundant tie is a link that when, removed from the ego network, breaks the ego network into two or more sub-networks (or components). A component is a part of the network that is unreachable from another component because there are no ties connecting the components. The lack of relationships between the partner firms of the focal firm gives the focal firm more discretion in its actions because partner firms cannot coordinate action against the focal firm. Non-redundant partner firms give access to new information and resources (McEvily & Zaheer, 1999). We define a structural hole (based on Burt, 1992: 18) as:

> **Definition 13: structural hole:** is the absence of a direct relationship between two firms who have a third firm in common and these two indirectly connected firms are (partially) dependent on each other.

There is some conceptual ambiguity in the literature about what constitutes a structural hole. For example, Burt (1992: 18) refers to a structural hole as a non-redundant tie that connects two actors. In this case, the focus is on the existence of the tie. However, the focus is sometimes on the absence of the tie between two indirectly connected firms (1992: 38-43). The absence of a direct tie between two firms that are indirectly connected to each other is the structural hole. It is the bridging (or non-redundant) tie (McEvily & Zaheer, 1999) that spans the structural hole. The structural hole contains potential information and control benefits, but the bridging tie unlocks these information and control benefits. See also Figure 2-2 for an illustration of these different concepts. For the purpose of this study, we define a bridging position and bridging tie (based on Friedkin, 1980: 411) as:

> **Definition 14: bridging tie:** the sole relationship by means of which two actors (and their direct contacts) are connected in a network. A bridging tie will also be referred to as a non-redundant tie.

> **Definition 15: bridging position:** a network position (definition 12) that is characterized mainly by bridging ties (definition 14). For example, the central node in a star network occupies a bridging position.

When an insurance firm establishes a shared service center and opens it up for competitors to use it as well and multiple insurance firms use this shared service center then the insurance firm owning the shared service center is occupying a bridging position.

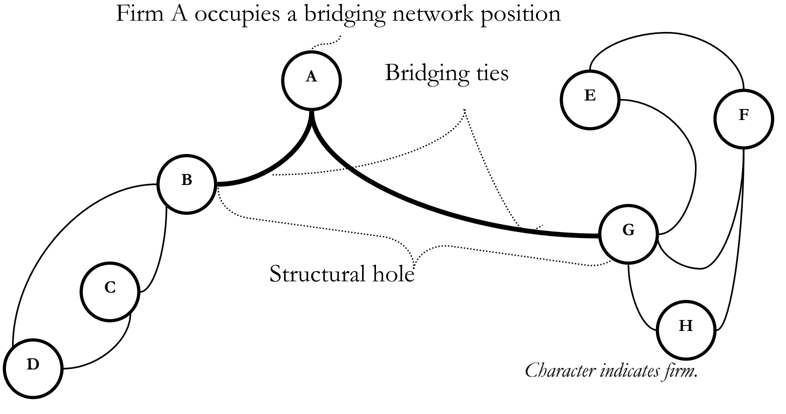


Figure 2-2 Illustration bridging network position, structural hole and bridging ties

2.2.2.1 Bridging positions create information benefits

Information benefits of a structural hole are access, timing and referrals (Burt, 1992). Access refers to receiving valuable information and knowing who benefits from that information. Timing refers to receiving the valuable information before other firms do and thereby having the opportunity to act upon that information itself or pass it through to its partner firms. Referrals refer to partners of the focal firm who direct, concentrate, and legitimate information about the focal firm to other firms in the network. This makes the focal firm more attractive as an ally because partner firms legitimize the focal firm.

Information benefits accrue to a firm spanning structural holes since this increases its network range (Reagans & McEvily, 2003). Network range is the diversity of firms that the focal firm connects with; a greater diversity means more information benefits because different firms are likely to have different information (Koka & Prescott, 2002). These information benefits allow a firm to increase its performance because the focal firm, which occupies a bridging position, is able to exploit the information asymmetry between its partner firms. Figure 2-2 illustrates how firm A benefits from the information asymmetry between firm B and firm G. Firm A knows what firm B and firm G know but also what they need while this is only partly true for firm B and firm G. Firm A has more information and a better understanding of how to benefit from this information. However, a firm will only benefit from this information when an important assumption in structural hole theory is satisfied. This assumes that information benefits of a structural hole only exist when the partner firms have unique information, i.e. they are non-substitutable for each other (Reagans & Zuckerman, 2006). A non-substitutable firm has unique information that the other firm does not possess. What the effect is of substitutable partners is the topic of the next section.

2.2.2.2 Bridging positions create control benefits

The control benefit is to execute the *tertius gaudens* strategy (Burt, 1992), or the third party who benefits. Control benefits accrue to a bridging firm if its partner firms cannot orchestrate collective action against the bridging firm. The lack of relationships between partner firms impedes the coordination of their actions. This gives the bridging firm the opportunity to play those firms off against each other.

For example, suppose that firm B and firm G in Figure 2-2 are buyers for a product that only firm A sells. In that case, firm A can leverage its bargaining position to negotiate favorable terms for a deal, because both buyers do not have alternatives and cannot coordinate their negotiations due to the absence of a relationship between firm B and firm G. In this case, A can play the *tertius gaudens* strategy because firm B and G cannot coordinate their actions against A. Control benefits make a firm less constrained because the partner firms are not aware of each others' demands and cannot develop a coalition to counter balance the firm that spans the structural hole. An important assumption behind the control benefits of a structural hole is that the partner firms are substitutable for each other (Reagans & Zuckerman, 2006). Substitutable partner firms create control benefits for the focal firm but this comes at expense of foregoing the information benefits, while non-substitutable partner firms create information benefits but at the expense of control benefits.

2.2.2.3 How information and control benefits increase firm performance

Figure 2-3 illustrates how the information and control benefits lead to increased firm performance.

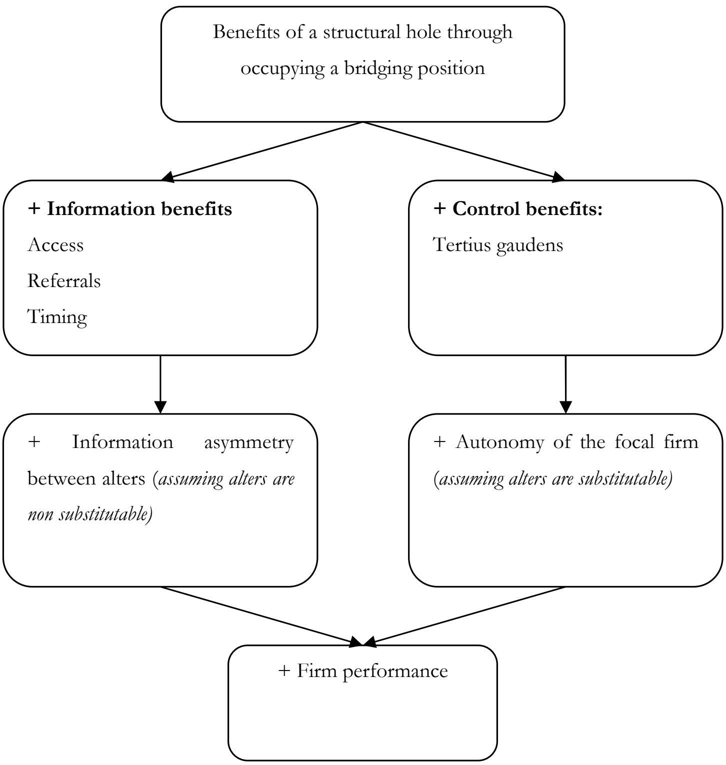


Figure 2-3 How bridging positions increase a firm's performance

Both the information and control benefits are based on the assumption that a firm is better off if it maximizes both the resource asymmetry and information asymmetry between its partner firms.

2.2.3 How closed positions increase firm performance

Network closure is a different method to improve firm performance (Coleman, 1988). Networks with closure are networks in which many alter-alter relationships exist; i.e. such networks are dense because many potential relationships in fact exist and thus there are many direct links between the members of the network. Closure creates three benefits: 1. effective sanction mechanisms; 2. shared mental maps; and 3. reputation effects. We will first define network closure more formally and continue with reviewing the effects of network closure. Coleman (1988) does not give an explicit definition of closure, but closure refers to a situation where information about behavior is easily transmitted because there are many relationships between the alters of the focal firm. As the number of relationships increases, the likelihood that a single relationship becomes the critical path determining whether information can freely circulate diminishes. For the purpose of this study, we define network closure and closed position as:

> **Definition 16: network closure:** when the ego network (definition 10) of the focal firm consists of at least two partner firms and a minimum of two partner firms can be reached through at least two different paths through the ego network.

Thus, relationships in an ego network with closure are redundant: removing these relationships will not result in the creation of one or more components of the ego network.

> **Definition 17: closed position:** a network position (definition 12) that is mainly characterized by network closure (definition 16).

A path is a sequence of actors connected to each other with each actor only used once (Wasserman & Faust, 1994). Our definition of network closure differs from a clique. A clique is a maximum complete sub graph (Borgatti, Everett, & Freeman, 2002). This means that the density of a clique is one, thus all potential relationships exist. A clique will automatically have network closure while network closure does not automatically imply a clique. Thus, a clique is an example of a pure closed network position. See Figure 2-4 for an illustration of the difference between network closure and a clique.

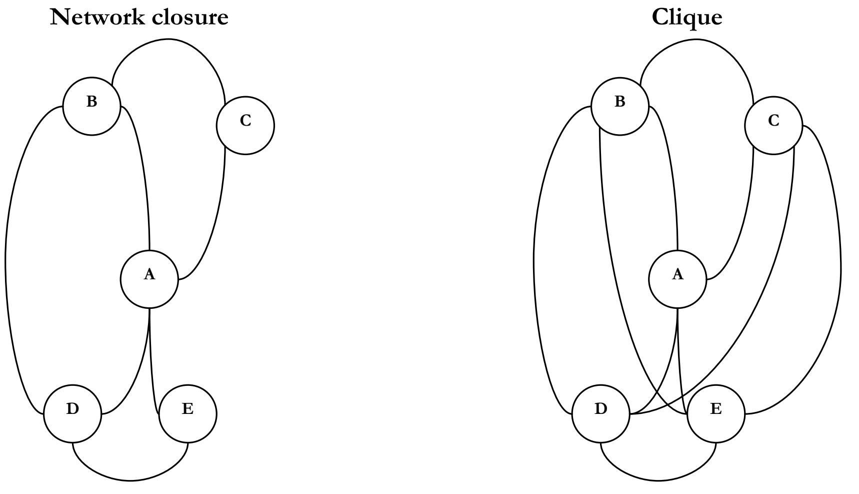


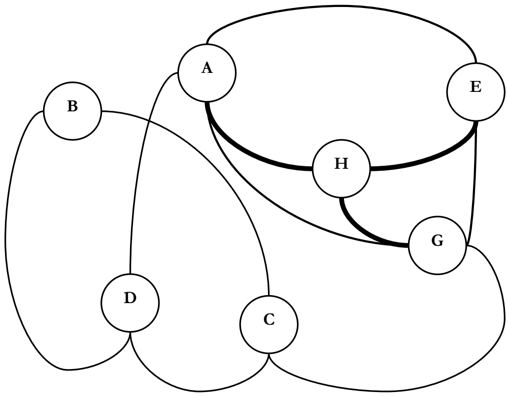
Figure 2-4 Illustration of network closure and a clique

Not all alters have to be reachable through two different paths: the alters that are not reachable through two different paths are not part of the closed network position (for example the triad of firm A, C and E does not have network closure in the picture left). A firm with an ego network characterized by network closure occupies a closed network position. A complete closed network position is the situation where a firm belongs to a clique. Figure 2-5 is an illustration of a closed network position. The ego network of firm H consists of three partner firms A, E, and G: each of these firms is connected to one another as well. Each firm in H's ego network is reachable through at least two different paths. For example, firm A can reach firm E directly, through H or through G.

Closed network positions exists because of the existence of alter – alter relationships while bridging positions exist due to the lack of alter – alter relationships. These two positions represent the two extremes on a continuum of the density of an ego network. A sparse ego network is an indicator for a bridging position while a dense ego network is an indicator for a closed position.

2.2.3.1 Closed positions create an effective sanctioning mechanism

The literature on network closure identifies three benefits. The first benefit of network closure is that such networks are better able in effective sanctioning (Coleman, 1988). Free rider problems are less likely to happen in a network with closure because firms will be quickly aware of a firm that shirks.



Character indicates firm.

Figure 2-5 Illustration of a closed network position and network closure

The reason is that many alternative links exist between the various firms and if one of the firms shirks then information about the shirking firm will quickly transmit through the network. Moreover, these firms can act jointly against the shirking firm. Therefore, being able to sanction effectively increase the trustworthiness of firms and therefore it is possible to lower transaction costs and create a more efficient coordination mechanism that facilitates cooperation.

2.2.3.2 Closed positions facilitate shared understanding

The second benefit is that networks with closure are better equipped to reinforce shared values (Coleman, 1988) by reducing cognitive distance of the actors through the creation of shared mental maps and shared behavioral expectations (Rowley, 1997). These shared mental maps facilitate the transfer of tacit or complex knowledge (Hansen, 1999) and strengthen interorganizational trust. Networks with closure are often characterized by frequent interactions because of the existence of many relationships between the firms. Frequent interactions increase the richness of communication and these rich interactions foster a shared understanding of goals, expectations, and behaviors.

2.2.3.3 Closed positions create an effective reputation mechanism

Third benefit: network closure influences a firm's reputation. Information about the behavior of a firm is quickly transmitted through the network. When a firm shirks, acts opportunistic or violates the shared expectations in another way then other firms will be quickly aware of these facts because information flows easily through a dense network because no actor or firm is able to control the flow of information. This will harm the reputation of the firm that committed these acts because it has a hard time hiding its behavior. The subsequent reputation damage will make such a firm a less attractive network partner and therefore is network closure an effective reputation mechanism because it increases the shadow of the future (Axelrod, 1984).

2.2.3.4 How effective sanctioning, shared understanding and effective reputation mechanism increase firm performance

These three network closure benefits (ability to sanction effectively, shared mental maps and reputation) are based on reduced information asymmetry between the firms through multiple paths in the network. The consequences of the these benefits are that it reduces alter-centric uncertainty (Podolny, 2001) as well as opportunistic behavior. Alter-centric uncertainty is uncertainty that the focal firm has about the intentions, behaviors and performance of its alters (Podolny, 2001). Alter-centric uncertainty is reduced because information about firm behavior flows freer through the network and hence firms are more aware of each other's actions. Firms with closed network positions have multiple sources to acquire information about a firm and this gives more credibility to the information and increases the probability of receiving that information. The effect of having multiple sources to acquire information about a firm is that a firm's behavior becomes more transparent and this reduces alter-centric uncertainty. Less alter-centric uncertainty creates an environment that is more conducive to sharing of information.

Opportunism is reduced because the penalties for such behavior become too large in the form of effective sanctions and costs of lost of reputation. Because firms occupying a closed network position generally cooperate for a longer period with each other (see section 2.2.4.2) there is a longer 'shadow of the future' (Axelrod, 1984) that prevents firms from behaving opportunistic. Interorganizational trust and interfirm information transfer increase through the reduction of alter-centric uncertainty and smaller chances of opportunistic behavior. Subsequently, increases of interorganizational trust reduce interfirm coordination costs (Zaheer, McEvily, & Perrone, 1998). Finally, increased information transfer and a reduction of interfirm coordination costs increase a firms' performance.

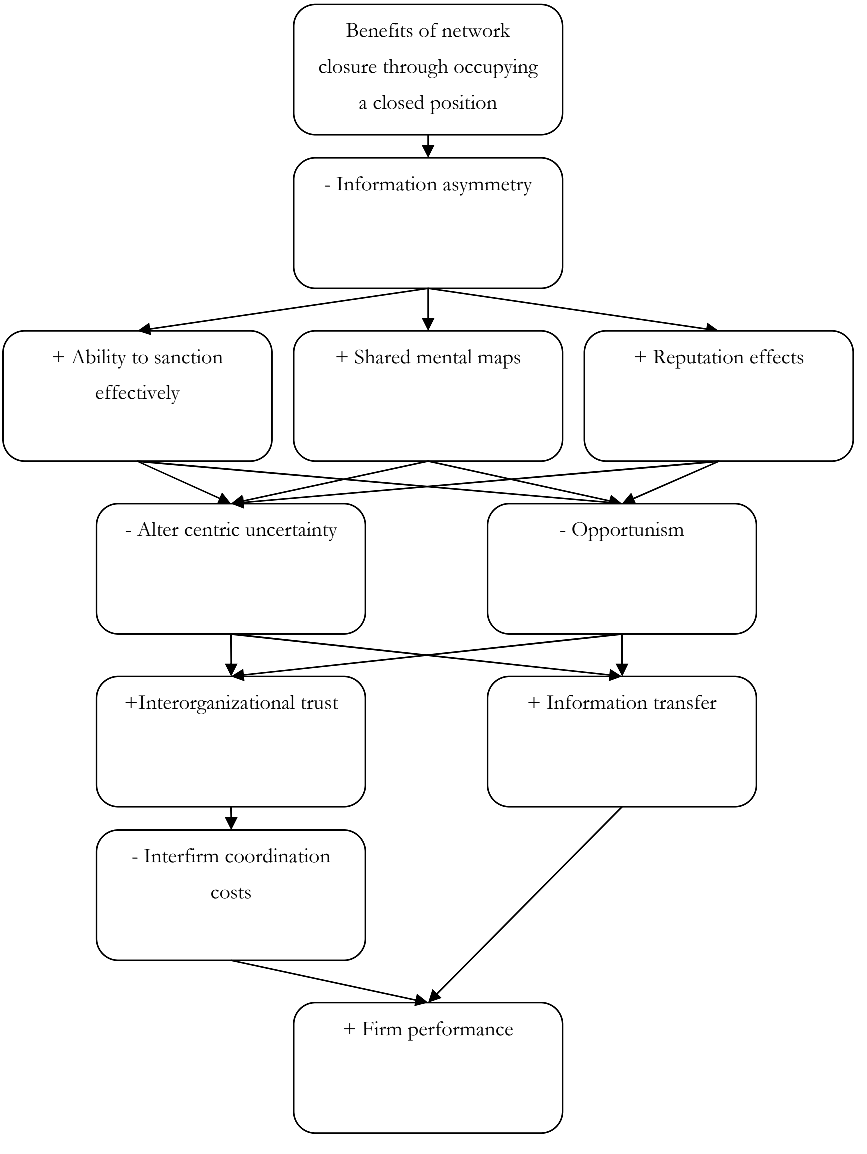


Figure 2-6 How closed network positions increase firm performance

2.2.3.5 Previous findings of bridging and closed positions on firm performance

We conclude the section on the relationship between the bridging and closed network position and firm performance with an overview of research that has investigated this relationship.

Study	Industry	Performance measure	Network position (measure used)	Finding
Ahuja (2000a)	Chemicals	Patent count	Bridging position (effective size measure)	Negative
Bae & Gargiulo (2004)	Tele-communication	Return on investment Return on assets	Bridging position (ego density measure)	Positive Positive
Baum, Calabrese and Silverman (2000)	Biotechnology	Revenue Growth patent rate Growth R&D expenses	Bridging position (efficiency measure)	Positive Positive Positive
Baum, van Liere and Rowley (2006)	Investment banking	Market share	Bridging position (effective size) Closed position (ego density measure)	Positive Positive
Echols and Tsai (2005)	Venture capital	Number of successful IPO's	Bridging position (effective size measure)	Positive
Gnyawali, He & Madhavan (2006)	Steel	Competitive activity Competitive variety	Bridging position (inverse constraint measure)	Positive Positive
McEvily and Zaheer (1999)	Regional industrial extension centers	Access to capabilities	Bridging position (ego density)	Positive
Rowley, Behrens and Krackhardt (2000)	Steel and semiconductor	Return on assets	Closed position (density)	Negative
Rowley and Baum (2002)	Investment banking	Market share	Bridging position (effective size measure)	Positive
Rowley and Baum (2004)	Investment bank	Market share	Bridging position (effective size)	Positive
Shipilov (2006)	Investment bank	Market share	Bridging position (efficiency measure)	Positive
Soda, Usai & Zaheer (2004)	Television productions	Number of viewers (log)	Bridging position (constraint measure) Closed position (density measure)	Positive Negative
Walker, Kogut & Shan (1997)	Biotechnology	Establishing a new interfirm relationship	Bridging position (structural equivalence measure)	Negative
Zaheer and Bell (2005)	Mutual fund industry	Market share	Bridging position (constraint measure) Closed position (constraint measure)	Positive Negative

Table 2-1 Overview research link between network position and firm performance

The conclusion of this table (Table 2-1) is that bridging positions have often been found to increase firm performance in transaction type networks like investment banking. These findings are robust across different industries using different performance measures.

2.2.4 Differences between bridging and closed positions

Both structural hole and closure theory have the ego network as the unit of analysis. Structural hole theory emphasizes the importance of the lack of alter – alter relationships in the ego network while closure theory emphasizes the importance of the existence of alter – alter relationships in the ego network. Thus, both structural hole and closure theory focus on alter – alter relationships but emphasize either the existence or lack of these alter – alter relationships. This section will discuss how bridging and closed positions differ in terms of value creation mechanisms, emergence of the position and boundary conditions.

2.2.4.1 Value creation mechanisms: information asymmetry vs. information symmetry

The first important difference between a bridging and closed network position is that information asymmetry in a closed network position is low compared with a bridging position. Multiple paths in the ego network facilitate increased diffusion of information. This means that none of the firms has complete control of the information flow in a network and hence cannot / will not prevent the transfer of information. This is in contrast with the bridging position in which a firm is able to control (to a certain extent) the flow of information. Asymmetry of information about behavior, opportunities (referrals) and access to knowledge is likely to be small because a closed position facilitates the communication flow. Furthermore, a closed position eases information transfers due to the existence of multiple paths in the ego network and hence reduces the probability that a firm stays unaware of specific information and increases the trustworthiness of firms because firm behavior is more transparent and sanctions are more effective. The coordination costs and the probability that a firm behaves in an opportunistic way will decrease as the effectiveness of these mechanisms increases. It becomes unfeasible for the focal firm to execute a *tertius gaudens* strategy because the partner firms are well connected. Their well-connectedness gives the partner firms the opportunity to coordinate their actions against the focal firm that tries to play them off against each other. A firm occupying a bridging position is more likely to maintain the information asymmetry to strengthen its information and control benefits.

In contrast, a firm occupying a closed position is more likely to reduce the information asymmetry in order to increase the effectiveness the reputation and sanction mechanisms.

A firm occupying a bridging position creates value in two distinct ways. First, it moves information strategically from one firm to another firm and is able to control this information flow. Such a position creates the most value by maximizing the information asymmetry between the alter firms. As the information asymmetry between partner firms increases there will be a greater need for a broker to orchestrate the information flow. This assumes that partner firms are heterogeneous: each firm possesses information that the partner firms do not have but each firm would benefit from having it (Reagans & Zuckerman, 2006).

Second, a firm occupying a bridging position holds a stronger bargaining position when it acts as a buyer and has unconnected suppliers. The suppliers are not able to coordinate their negotiations because of the information asymmetry between them, and the bridging firm is able to execute the *tertius gaudens* strategy to obtain a deal with favorable terms.

2.2.4.2 Emergence of network positions: partner dependence vs. resource dependence

The second difference between bridging and closed network positions concerns the emergence of such networks. Closed network positions take more time to develop and the success of a closed network position is highly dependent on the partnering actions from the partner firms. Spanning of structural holes is a property of an individual firm, but closure is a network property not attributable to one single firm. A closed network position exists because there are many alter – alter relationships. Such a network position is not quickly established (Soda et al., 2004). More frequently it is the consequence of a complex partnering process due to the fact that firms, in order to search locally and to avoid uncertainty (Cyert & March, 1963), tend to partner with past partners (Gulati, 1995a) or with new partners through referrals (Uzzi, 1996). This means that firms tend to ally with firms that can be reached in two steps or less (Baum, Rowley, Shipilov, & Chuang, 2005). These two processes lead to the creation of cliques within the network (Rowley, Baum, Shipilov, Greve, & Rao, 2004; Rowley, Greve, Rao, Baum, & Shipilov, 2005) and therefore it takes time for a closed network position to develop because it is dependent on the partnering decisions by its partner firms. An example of this process is illustrated in Figure 2-7:

1. The network starts with two dyads and one isolate in panel 1 of Figure 2-7
2. Next, firm A establishes a tie with firm C (panel 2).
3. In panel 3 firm A introduces firm C to firm B and thereby legitimizes firm C and firm B connects with firm C. In essence, firm A is acting as the tertius iungens, the third who joins (Obstfeld, 2005).
4. The two separate clusters (cluster A-B-C and cluster D-E) are joined in step four by firm C who establishes a bridging tie with firm D.
5. Next (panel 5) firm C introduces firm D to firm A and firm D connects with firm A.
6. Finally, in panel 6, firm D and firm B connect to each other and firm E connects to firm C. Hence, the initial ties of the focal firm are an important determinant of future ties for as long as the focal firm continues establishing local ties based on past partners and referrals.

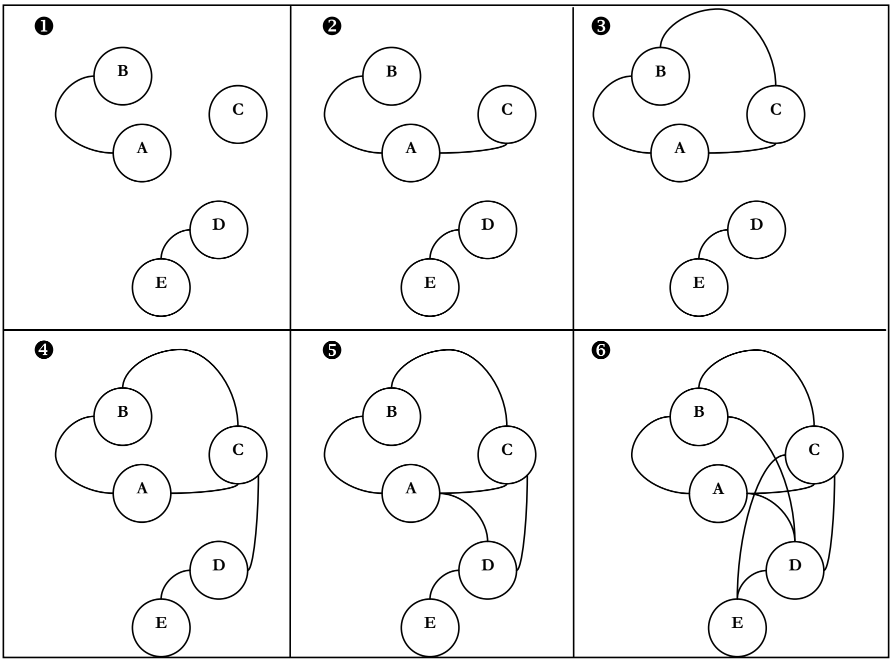


Figure 2-7 Emergence of a closed network position through past and referral partnering

Consequently, it takes time for firm A to develop a closed network position because it is partly dependent on the partnering actions of its alters. It is more likely that a firm with a closed position aims at stimulating the creation of redundant ties in order to strengthen the sanction mechanism and the reputation mechanism. In contrast, a bridging firm is more likely to find new firms to link with that offer new and complementary resources.

A different strategy is to build a bridging network position. Such a network position is not dependent on the actions of partner firms. However, maintaining such a position is dependent on the partnering actions of partner firms. Partnering decisions of alter firms can possibly weaken the bridging position of the focal firm. Establishing a bridging tie is the decision of two firms that are directly linked: the focal firm and the new partner firm. Being able to find new partners - and link with them - is influenced by two important factors: the attractiveness of the focal firm and the information the focal firm has about the network to locate brokerage opportunities. A focal firm will be more attractive when it possess or has access to valuable resources that are needed by other firms in the network. If this is the case, there will be a clear incentive for the new firm to link with the focal firm. Thus, a firm trying to create a bridging position is dependent on two factors: first it needs to have valuable resources to make it an attractive partner (Ahuja, 2000b), second it needs information about the network to be able to locate future partner firms.

2.2.4.3 Boundary conditions: transaction vs. knowledge intensive network contexts

The third difference between bridging and closed positions is concerned with the boundary conditions of each position. Recent research suggests that there are empirical settings that do not favor spanning of structural holes. Burt (1992) assumed that the information and control benefits are conceptually distinct but that these benefits strengthen each other. Burt puts it as follows: (1992: 48) "The information and control benefits are multiplicative, augmenting and depending on one another, together emerging from the wellspring of structural holes in a network".

However, Reagans and Zuckerman (2006) argue that these two benefits make conflicting assumptions about the characteristics (homogenous vs. heterogeneous) of the partner firms. Information benefits can only accrue to the bridging firm if its partner firms are heterogeneous while the control benefits can only accrue to the bridging firm its partner firms are homogeneous. These two implicitly different assumptions may have been the cause that structural holes have been found to impact innovation negatively (Walker et al., 1997). Sometimes it is more beneficial to reduce information asymmetry.

For example, innovation is typically achieved by applying knowledge from one context in a new context (Hargadon & Sutton, 1997): this is achieved by way of sharing of knowledge. Sharing resources, information, and knowledge becomes a key process for the output rate of new products or innovations. Bridging positions in these types of environments will result in bottlenecks that adversely affect performance: The flow of information is easily distorted due to the lack of alternative routes through the network. Therefore, some studies suggest that structural holes influence innovation negatively (Ahuja, 2000a; Walker et al., 1997). Walker et al. (1997), Ahuja (2000a) and Obstfeld (2005) suggest that occupying a bridging position in a knowledge intensive context has detrimental consequences for firm performance (measured as innovation output). Walker et al. (1997) suggest that spanning structural holes is probably most beneficial in transaction networks. Transaction networks are networks that focus on the production or acquisition of a good or service. Examples of transaction networks include investment syndicate networks (Pollock, Porac, & Wade, 2004) and vertical networks (Dyer, 1996; Lorenzoni & Lipparini, 1999). The remainder of this study will focus on transaction networks. Table 2-2 summarizes the differences between bridging and closed network positions.

	Bridging position	**Closed position**
Value creation mechanism	Information asymmetry	Information symmetry
Emergence of the position	Resource dependence	Path dependence
Boundary conditions	Transaction networks	Knowledge intensive networks

Table 2-2 Summary of the differences between bridging and closed positions

So far, we have reviewed the benefits of bridging and closed positions and we have discussed how they differ. These positions are an important means to improve a firm's performance and therefore it is important to understand how these positions emerge, why these positions last, and why these positions eventually may disappear. Therefore, we will discuss the literature on the dynamics of network positions in the next section.

2.3 Dynamics of Network Positions at the Firm Level

How do firms create and sustain a bridging or closed network position? This section reviews how firms improve their network position through partnering decisions - and how these decisions are being influenced, or constrained, by network structures. A firm can change its network position through two different types of actions: it can establish a new relationship or it can disband an existing relationship (Koka, Madhavan, & Prescott, 2006). The literature about network change emphasizes that interfirm networks are dynamic (Koka et al., 2006; Moldoveanu et al., 2003; Powell et al., 1996; Powell, White, Koput, & Owen-Smith, 2005). Network positions change because firms in a network decide to establish new ties or disband current relationships to improve their current position (Madhavan et al., 1998; Rowley & Baum, 2002). Firms expand their network by creating new interorganizational ties and disbanding old ones. However, there is also ample evidence that interfirm networks are characterized by stability (Rowley et al., 2005), also referred to as "network inertia" (Kim, Oh, & Swaminathan, 2006). Therefore, we review both drivers of change and forces of inertia. Furthermore, scholars suggest different motivations for changes in network positions at different levels: environmental (Koka et al., 2006), relational (Rowley & Baum, 2002), firm (Shipilov, Rowley, & Aharonson, 2006), and cognitive (Baum et al., 2005). Hence, we will categorize the motivation to change as well.

2.3.1 Environmental drivers of network position change

Madhavan et al. (1998) argue that there are two types of exogenous shocks in a firm's environment: structure loosening and structure reinforcing events. Structure loosening events are initiated by peripheral firms and have a negative impact on the current network position of the core firms. For example, Google entering the Internet search industry was a structure-loosening event because the introduction of a new superior search technology made incumbent Internet search firms less attractive and Google an attractive alliance partner. Structure reinforcing events are events initiated by the current dominant firms to protect or expand their current network position at the expense of peripheral firms. Madhavan et al. (1998) present in their empirical study of the U.S. alliance industry two exogenous developments: the combined introduction of a new production technology and deregulation of institutional barriers to cooperate changed the alliance network. The introduction of a new production technology was a structure-loosening event that gave peripheral firms the opportunity to improve their network positions while the deregulatory changes favored the dominant firms in protecting their network positions. These examples are exogenous shocks in the environment and do not find their origin in the network itself.

2.3.2 Relational drivers of network position change

Resource misfit can occur when partner firms no longer require the resources for which they established their relationship in the first place because the need for a particular resource diminishes. This could happen as a partner firm enters a new phase in its life cycle (Hite & Hesterly, 2001). For example, in their study of client – auditor relationships, Levinthal and Fichman (1988) show that as a client firm matures, its specific needs from its auditor change as well. These changing resource needs lead to a resource misfit. The auditor cannot offer the services of the client firm and hence the client decides to search for another auditor.

2.3.3 Structural drivers of network position change

The first structural motivation for network position change is firm-specific uncertainty. Firm-specific uncertainty is uncertainty unique to a firm and not in common with other firms. Firms establish new ties with firms to alleviate this type of uncertainty because these new firms are a source of information through experience or knowledge (Beckman, Haunschild, & Phillips, 2004). For example, a firm can collaborate with another firm that has experience in entering a particular market, or has experience in marketing a particular product. The focal firm can benefit from the experience and knowledge of the new partner (Beckman & Haunschild, 2002).

A second structural cause for a shift in a firm's network position are the partnering decisions of competitors. A firm entering an alliance is likely to benefit from the access to new resources, markets, and information. The benefit the focal firm is generating from an alliance is likely to affect negatively a competitor (Silverman & Baum, 2002). For example, resources become scarcer or competition increases. Thus, the partnering action of the focal firm is likely to be responded by a partnering action of a competitor to defend its own competitive advantage (Gimeno, 2004). This sequence of partnering decisions is likely to continue as competitors respond to each others moves (Chen, 1996; Gulati, 1998). Concluding, the partnering actions of a competitor may force the focal firm to respond by initiating new interfirm relationships to offset the potential advantages of the relationship the competitor established.

2.3.4 Cognitive drivers of network position change

A cognitive motivation for a firm to shift its network position is its aspiration level. As companies engage in monitoring of competitors, they compare differences in firm performance. Baum et al. (2005) show that companies whose performance is significantly below or above their own aspiration level will engage in establishing non-local ties. A firm initiating a new tie to a firm that it could not reach in fewer than two steps before the tie was established is called a non-local tie. The rationale is that firms performing above their set aspiration level have excess resources to allow for experimentation. Hence, firms with additional resources can afford establishing a non-local tie from which the pay-off is uncertain. The alternative explanation why a firm will establish a non-local tie is when a firm performs below its aspiration level. In these cases, there will be pressure from stakeholders to improve performance. Alternative paths to improve performance have to be explored. Establishing a non-local tie is a means to explore and to access new information and resources that can be used to improve performance.

2.4 Inertia of Network Positions at the Firm Level

Interfirm network research implicitly adopts an adaptation view on interfirm network change (Kim et al., 2006) assuming that firms will conduct a cost - benefit analysis of interorganizational ties: If the economic benefits of the tie do not outweigh the costs then the tie will be disbanded. However, such an instrumental view may be too stylistic on how firms shift their network positions. It may ignore the inertial nature of firms and their difficulties to adapt to their environment. Network inertia is defined as (Kim et al., 2006: 704): “a persistent organizational resistance to changing inter-organizational dyadic ties or difficulties that a firm faces when it attempts to dissolve old relationships and form new network ties”. Potential causes for network position inertia are: environmental, relational, structural, and cognitive (Maurer & Ebers, 2006). Each category (environment, relational inertia, structural inertia, and cognitive inertia) has distinct motivations identified in literature.

2.4.1 Environmental forces of network position inertia

A firm can become network inert from an environmental perspective when it deals with high levels of market uncertainty. Market uncertainty is uncertainty that is common to all the firms from the same industry (Beckman et al., 2004). Examples include (changes in) customer demand, competitive uncertainty and input cost uncertainty (Beckman et al., 2004). Beckman et al. (2004) argue that depending on the type of uncertainty a firm faces, it will initiate different actions to cope with this uncertainty. Firms facing high levels of market uncertainty will strengthen their current interfirm relationships. The motive is that market uncertainty is external to the firm and shared across all the firms within the same industry. There are no information sources available within the industry that would lessen the market uncertainty and therefore a firm will not benefit from establishing new interfirm relationships. Firms seek stability to cope with market uncertainty by reinforcing existing relationships because interfirm trust has been established (Gulati, 1995a) and a firm is less uncertain about the behavior of its past partners.

2.4.2 Relational forces of network position inertia

The first account of a relational inert explanation why firms do not change their network positions is because significant amounts of resources have been invested in partner specific assets (Dyer, 1996; Dyer & Singh, 1998; Gimeno, 2004). Partner specific or co-specialized assets are assets that are developed through mutual investment with the sole purpose of being used in that particular relationship. Such assets are, for example, interorganizational information systems (Bensaou, 1997), joint development facilities or joint manufacturing facilities (Santoro & McGill, 2005). There are two effects of this type of investments. One, these assets create a lock-in effect in a relationship because of the sunk costs and high switching costs that are associated with the development of these assets. Investments in partner specific assets will result in procedures that facilitate information and knowledge exchange (Santoro & McGill, 2005). Second, over time, these procedures will become more institutionalized and hence harder to change. Both the costs of partner specific investments and the institutionalization of partner specific investments reduce the likelihood that a firm will shift its network position.

A second explanation of relational inertia is offered by Levinthal and Fichman and Fichman and Levinthal (1991; 1988) who show in their studies of auditor-client relationships that interorganizational relationships are characterized by a 'honey-moon' period. At the start of an interorganizational relationship, there is a stock of goodwill and resources that make it less likely that one of the firms will terminate the relationship. After the honeymoon period, when firms run out of the initial stock of goodwill and resources, they enter a period of 'adolescence' that is characterized by an increased probability of the termination of the interorganizational relationship. The probability that one of firms terminates the relationship increases because both firms have learned the benefits of the relationship and have a more objective assessment of the success (or lack of success) of the relationship. This objective assessment in combination with depletion of the initial stock of resources increase the probability that one of the firms will start looking for a more suitable partner and hence terminate the current relationship.

2.4.3 Structural forces of network position inertia

Overembeddedness is the situation in which a firm does not have any arm's length or market relationships but only strong and embedded ties. Uzzi (1997) argues that the mix of arm's length and embedded ties is important for a firm's performance. A firm whose portfolio of relationships only exists of arm's length relationships is more likely to experience opportunistic behavior because the firm does not have *ex post* social safeguard mechanisms like a reputation mechanism to prevent such unwanted behavior. On the other hand, a relationship portfolio that only consists of embedded ties results in overembeddedness (Uzzi, 1997). Overembeddedness causes high dependence on the partner firms that in turn decreases access to new and novel information because there are no links to other firms outside the ego network of the focal firm. High dependence can even result in social obligations becoming more important than the economic rationale of the relationship in the first place. These social obligations can result in helping out struggling firms which in the end will hurt the helping firm (Uzzi, 1997). These strong social obligations and the tendency to focus exclusively on the current partner firms increase the likelihood that the focal firm will stick to its current position and not look for new partners.

2.4.4 Cognitive forces of network position inertia

The institutionalization of a relationship is a cognitive explanation of network position inertia. Because partnerships worked in the past, there is little incentive to change them. Recurring partnerships increase interfirm trust (Gulati, 1995a), reduce behavioral uncertainty (Gulati, 1995b) and create mutual dependence (Holm, Eriksson, & Johanson, 1999). The lack of incentives, coupled with the institutionalization of partnerships (Osborn & Hagedoorn, 1997) makes it harder to terminate an interorganizational relationship: path-dependent processes create lock-in effects and may damage the reliability of the firm that severs the relationship. This lock-in effect and the possible reputation damage that may accrue by terminating the relationship prevent a firm to search for new partner firms and therefore to stay with its current partner firms.

A second explanation of cognitive inertia is the existence of shared mental maps. Repeated interaction with the same set of partners leads to a shared understanding of the environment through the formation of shared mental maps (Rowley et al., 2000). The same information about events and developments in the environment is shared: There is a tendency that firms interpret this information similarly (Porac, Thomas, Wilson, Paton,

& Kanfer, 1995). Deviating from these shared mental maps may lead to losing legitimacy and therefore firms are more likely to stay with the current situation rather than changing it.

A third explanation of cognitive inertia is that a firm is concerned about its reputation. The final cause why a firm might not shift its network position is due to loss of reputation. Dissolving a relationship with high investments in partner specific assets (Williamson, 1975) might signal untrustworthiness or opportunistic behavior to potential future partners who in turn will be less inclined to partner with the firm that has dissolved the asset intensive relationship. Acting in opportunistic way in a network is likely to have reputation effects because of the ease with which information about this behavior propagates through the network. A reputation mechanism acts as a voluntary restriction on a firm's behavior. The reputation costs may outweigh the benefits of acting opportunistically. This is in contrast with overembeddedness that can be viewed as becoming too loyal to a small set of firm and thereby voluntary restricting behavior not to jeopardize loyalty.

2.5 Dynamics of Network Positions at the Network Level

The previous section discusses the willingness of a firm to change its network position. However, even if a firm wants to change, its ability to effect a change in its network position is restricted by the structure of the network, i.e. the links (relationships) that are close to the firm in question. In the previous section, we focused on the network position of the focal firm and reviewed factors that contribute to change or inertia. We move our focus from the network position to the network structure as dependent variable in this section. This section takes a closer look at some of the network level formation processes: how do network structures emerge and how does the emergence and evolution of network structures impact the network positions of firms? There are two possible consequences that a network formation process can have on the individual network position of a firm: 1) the network formation process reinforces current network positions or 2) the network formation process weakens current network positions (Madhavan et al., 1998). It is important to consider the dominant network formation logic because the network formation process has repercussion for the strengthening or weakening of network positions. Before we address the different network formation processes, we first introduce the concept of network topology, which are "similar" network structures, and describe briefly their characteristics.

Definition 18: network topology: a family of network structures (definition 11) with similar structural properties.

Similar means that network structure properties, such as the degree distribution or centralization or average path length, are comparable. A specific network structure can be categorized as belonging to a network topology. Well known network topologies are "small world" (Milgram, 1967; Watts, 1999), "scale free" (Barabási & Albert, 1999), "core / periphery" (Borgatti & Everett, 1999) and "random graphs" (Erdős & Rényi, 1960a). A small world network is characterized by simultaneously high clustering (the presence of cliques) and short average path lengths. Cliques are maximally connected sub graphs (Borgatti et al., 2002). Scale free networks have a degree distribution that is characterized by a power law. The degree distribution of a network is the probability distribution of nodal degrees in a network. Due to the power law of the degree distribution is a scale free network characterized by a small number of nodes that act as hubs with a disproportionate share of the relationships while the majority of the nodes have few relationships. A random graph is a network in which each node has the same probability of having *n* relationships. The degree distribution in such a network approximates a uniform distribution, which is in contrast with a scale free network. A core / periphery structure is a network that can be partitioned in two parts: a set of highly connected nodes that form the core of the network and the periphery of the network. Peripheral nodes have some ties to the core, but peripheral nodes are weakly connected among other peripheral nodes.

2.5.1 Small worlds and random rewiring

It has often been observed that two seemingly unrelated actors can reach each other in surprisingly few steps. Such networks are often referred to as small worlds (Milgram, 1967; Watts, 1999). Watts' small world (1999) is created by starting with an initial network structure in which each node is connected to its neighbors and its neighbors' neighbors and has the shape of a donut. Subsequently, a fraction of the ties is randomly rewired creating bridging ties that significantly reduce the average path length. The result is a network structure that exhibits both clustering and short average paths. Small worlds have often been observed in empirical networks (Baum et al., 2003; Kogut & Walker, 2001; Uzzi & Spiro, 2005). The local clustering and short average path length make these network structures effective because they offer both the benefits from structural holes and closure and have a positive impact on financial performance (Baum et al., 2006; Uzzi & Spiro, 2005).

2.5.2 Small worlds and insurgent vs. control partnering

Baum et al. (2003) suggest two network formation mechanisms as alternatives for random rewiring. These two mechanisms are insurgent partnering and control partnering. Insurgent partnering is a process by which peripheral firms improve their network position through pursuing competitive information strategies (Moldoveanu et al., 2003) that aim at leveraging the information asymmetry between peripheral and core firms. Peripheral firms can shift their network position by exploiting the information asymmetry between the core firms, who generally are part of cliques with closed positions, and the peripheral firms' access to new and diverse information. Hence, they have access to valuable information that the core firms need and therefore are able to make the bridging ties that reduce the average path length in the network: this creates "small world" properties.

Control partnering is a homophilious argument ("birds of a feather flock together") stating that firms with similar attributes such as status (Podolny, 1993), are more likely to partner with each other. Peripheral firms that do not possess similar attributes are less desirable network partners and have more difficulty in shifting their network position. The core firm has more discretion in selecting the partner firms and therefore is more able to establish the bridging ties that connect the different cliques. Peripheral firms are responsible in the insurgent scenario for creating the small world; these firms initiate the bridging ties in order to improve their network position. Baum et al. (2003) state that all three scenario's, random rewiring, insurgent partnering and control partnering play a role in the evolution of an interfirm network: they believe that the main question is which scenario dominates at a particular point of time.

2.5.3 Scale free networks and preferential attachment

An often-cited network formation mechanism is preferential attachment (Barabási & Albert, 1999). Preferential attachment (Barabási & Albert, 1999) or accumulative advantage (Powell et al., 2005) is based on the idea that as networks grow, new nodes have a predisposition to connect with the node with the highest degree centrality. This leads to the formation of a few large hubs and the other nodes having a limited number of links. This is commonly referred to as a scale free degree distribution.

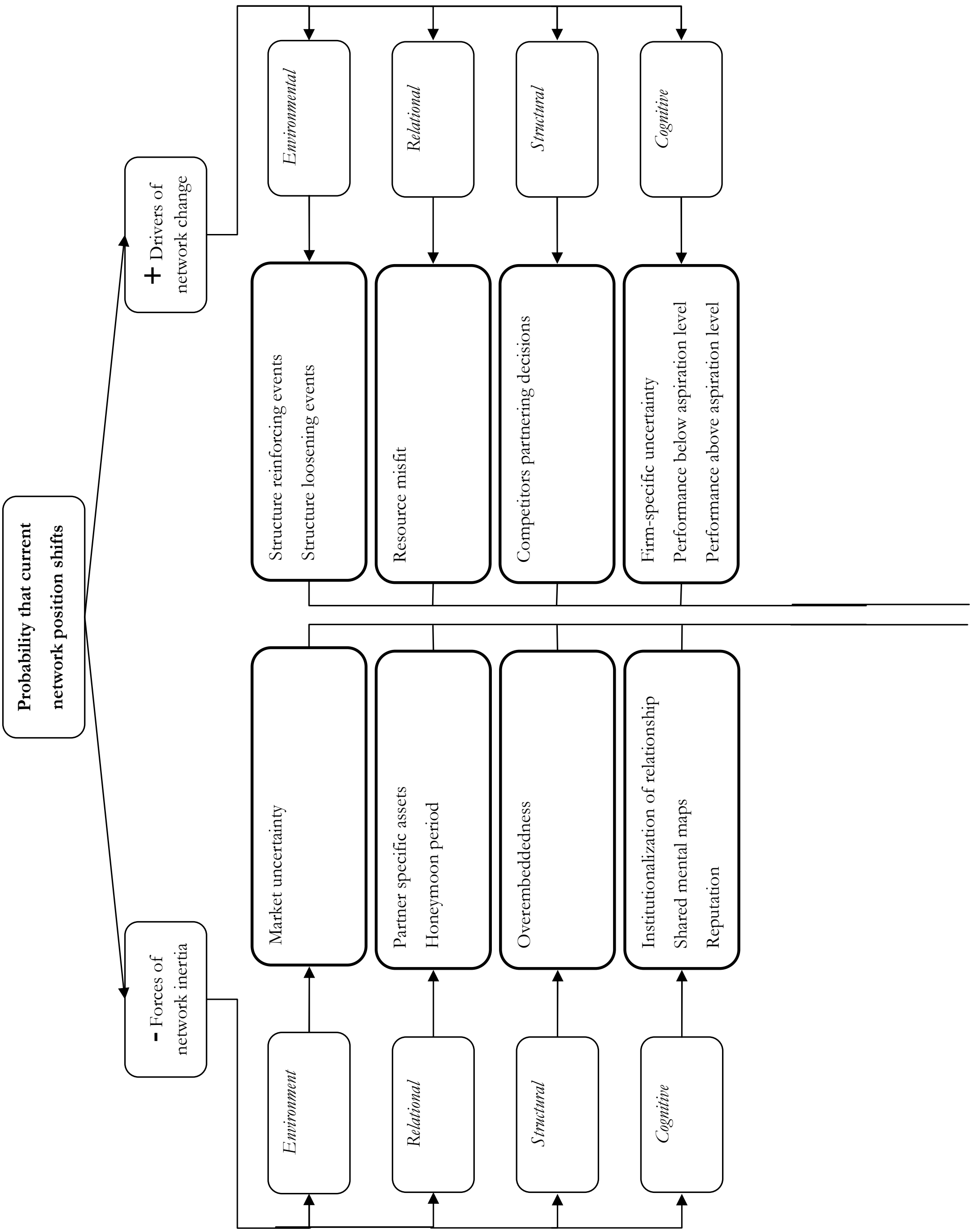
Preferential attachment has been proposed to explain the existence of scale free networks. A scale free network has a highly skewed degree distribution in contrast with a random graph where the degree is uniformly distributed; each node has the same probability of maintaining links with *n* firms. This mechanism implicitly assumes that each node is fully aware of the network structure and the creation of a tie has marginal costs of – or close to - zero. Although this mechanism does create a scale free network, it is not clear whether the causal mechanism is applicable to other contexts where there are costs associated with the creation of ties.

2.5.4 Follow-the-trend

The follow-the-trend network formation mechanism suggests that firms will mimic other firms when partnering with new firms and deciding what type of relationships they should maintain (Haunschild, 1993; Powell et al., 2005). Thus, a firm entering a network and behaving according to the follow-the-trend mechanism will partner with other firms according to the dominant logic of the network. It will choose the same firms and same type of relationships as other firms do. For example, if the dominant logic is to be part of a clique then this mechanism predicts that the new firm will try to join a clique as soon as possible. Firms adhering to a dominant logic will legitimize themselves because they signal to the incumbent firms that they know 'how things work'.

2.5.5 Past and referral partnering

The final network formation mechanism we describe is past and referral partnering (Gulati, 1995a; Uzzi, 1996). Past and referral partnering reflects risk-adverse behavior by firms in their partner selection process. Partner selection is surrounded with uncertainty, for example Shipilov et al. (2006) distinguish three types of uncertainty: partner capability uncertainty, partner competitiveness uncertainty, and partner reliability uncertainty. A firm is more likely to continue a relationship with a current partner to mitigate these concerns about potential partners. Referral partnering is the process when a firm introduces a current network partner to another network partner and these two unconnected firms establish a relationship. Such behavior in effect closes a structural hole. Past and referral partnering reinforce the current network structure and lead to dense cliques.


Probability that current network position shifts
+ Drivers of network change
- Forces of network inertia
Environmental
Relational
Structural
Cognitive
Structure reinforcing events
Structure loosening events
Resource misfit
Competitors partnering decisions
Firm-specific uncertainty
Performance below aspiration level
Performance above aspiration level
Market uncertainty
Partner specific assets
Honeymoon period
Overembeddedness
Institutionalization of relationship
Shared mental maps
Reputation
Environment
Relational
Structural
Cognitive

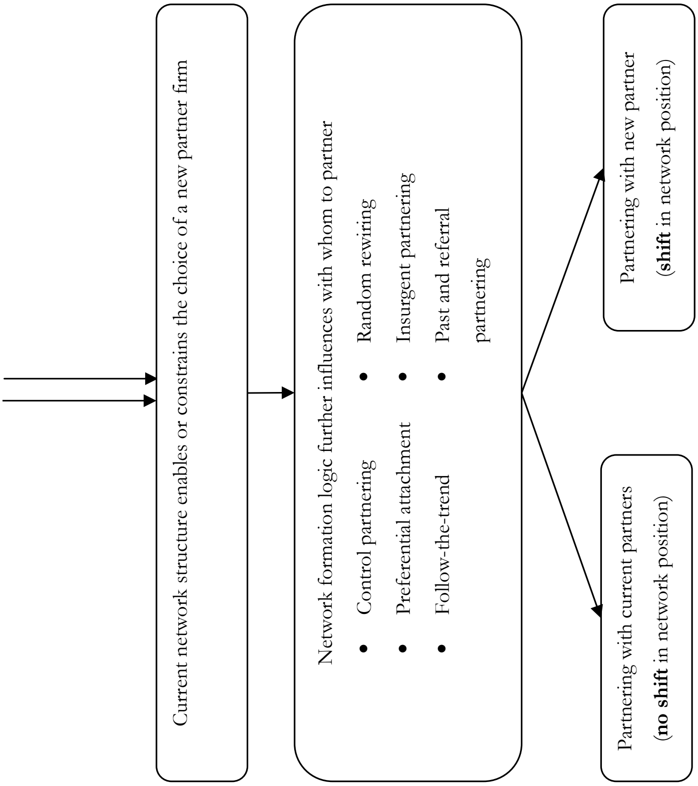


Figure 2-8 Overview current literature on network position dynamics

2.6 Critique on the Literature of Network Position Dynamics

The previous section assessed the dynamics of network positions from a network and firm level. The drivers of change and forces of inertia are summarized in Figure 2-8. Both Burt (2006) and Salancik (1995) argue that we should develop network explanations for network phenomena instead of relying on traditional theories to explain network phenomena. This has remained largely underdeveloped in the current literature on network position dynamics.

There are two main critiques on the current literature on network position dynamics. First, the literature takes account of drivers of change at the environmental, relational, and firm level but does not consider the network itself as an important source for a firm to change its network position. By incorporating the network as a driver for change, we can develop network explanations for network position dynamics. Some literature on environmental scanning demonstrates that firms gather information about their competitors (Daft & Weick, 1984; Hambrick, 1982) and use this information to decide whether a firm should respond to the strategic actions of a competitor (Chen, Smith, & Grimm, 1992). If firms in a non-networked environment respond to each other, why would firms not respond to each other in a networked environment (i.e. within the interfirm network)? Changes in network positions of rival firms mean that resources are likely to flow differently in the altered network and this can have favorable or detrimental consequences for the focal firm (Baum & Korn, 1999; Silverman & Baum, 2002). A strong bridging position can evaporate because partner firms initiate new ties that reduce their dependence on the bridging firm. Changes in the network structure result from changes in network positions of partner firms and can be an important necessity for the focal firm to change its network position.

Second, studies on network position dynamics have rarely taken into account how a particular, firm-specific network position changes. The focus has been on the establishment, or abandoning of ties: not whether it is a bridging or embedded tie, or how one type of position evolves into another type of position. There are some exceptions. Baum et al. (2005) study how aspiration performance levels increase the probability of establishing non-local or bridging ties. Rowley and Baum (2002) have studied the structural holes spanned by an investment bank. By explicitly taking into account what kind of relationships are being established or dissolved, we get a more detailed understanding of the dynamics of network positions.

2.7 Focus on Bridging Positions to Assess the Dynamics of Network Positions

In Chapter 1, we raised our overall research question: "Why does the network position of a firm change? and which firm, partner firm, and network factors accelerate or slow down this change process?" In order to answer the overall research question, we will narrow down the type of network position we will study. In this section, we will argue that the bridging position is an appropriate network position to study in order to increase our understanding of the dynamics of network positions. The bridging position seems to be the most appropriate network position to study for the following four reasons: 1) bridging positions are an important source of value creation (see for example Table 2-1 and Burt (2000)), 2) information about the network structure beyond the ego is needed to purposefully strengthen a bridging position, 3) bridging positions are particularly applicable to transaction networks and 4) bridging positions are more dynamic compared with closed positions.

2.7.1 Bridging positions are an important source of value creation

Bridging positions create value through information and control benefits: this gives the focal firm discretion as to whom to include or exclude, to determine the terms of a transaction and to make partners dependent. Structural holes are generally between actors from different groups. Differences between groups are likely to be greater than differences within a group (Burt, 2000). Thus, occupying a bridging position between groups is a source of value creation because information brokered between different groups is more likely to be additive than overlapping. Network closure may sometimes be needed to coordinate within the group but that is often a second step after bridging. Burt (2000: 416) concluded in his extensive review of structural holes and network closure that: "brokerage is the source of added value, but closure can be critical to realizing the value."

2.7.2 Bridging positions benefit from information beyond the ego network

The second reason why we choose bridging positions as the unit of analysis is that a firm requires a (part of the) blueprint of the network (the network "map") to detect brokerage opportunities. This is in contrast with the closed position, which is created through past and referral partnering, and hence firms have a smaller need for information about the network structure. The difference between these two extreme positions (bridging versus embedded) relates to information about the network structure. Bridging actors are keen to keep valuable information on the network structure to themselves, especially when they are pursuing a *tertius gaudens* strategy in order to maximize the information asymmetry. While closure actors want to share information among their partners in order to increase the effectiveness of the sanction and reputation mechanisms in order to minimize information asymmetry. Information on the alter-network, the alters' alters network, etc., or in general the complete network structure, is a decisive factor to acquire and sustain a favorable network position.

Without information beyond the ego network (i.e. the alter, or alter-firm network, the alters' alters, and so on), it is not possible for a firm to create bridging ties other than by chance. Information about the network can range from none to complete. If all firms in a network are without any information about the network structure then strengthening or weakening of bridging positions will be completely random.

Author(s)	Quotes about the information actors have about the network structure
Cook & Emerson (1978: 726)	"In the experiments in this series the subjects have no knowledge about structural arrangements remote from their own location."
Cook, Emerson & Gillmore (1983: 280)	"An important feature of our laboratory research is that the actors located in the structure have no knowledge of the network beyond their own opportunity set."
Hite & Hesterly (2001: 279)	"Emerging firms [] are less likely to know of the full range of potential market ties. Perhaps more importantly, however, newer firms are less likely to be seen as potential ties by other firms [] because they lack visibility."
Skvoretz & Willer (1993: 814)	"Finally, future research should use weak power networks to systematically explore the relationship between information and the development of power []. Yet theorists have long suspected that information available to actors can influence power differentials []. Our experiments were conducted in an open information context in which actors knew how their positions were connected in the larger network. With this information, subjects could make a cognitive assessment of their chances of exclusion and calibrate their behavior accordingly."
Gould (2002: 1152)	"…assume a closed and finite population of individuals, each of whom can direct attachments in any way he or she chooses across others in the population."

Table 2-3 Quotes about the information actors have about the network structure

Purposeful partnering with the intention to strengthen a bridging position is not possible because without information about the network structure it is not possible to detect brokerage opportunities. Networks with complete information about the network structure will evolve towards an equilibrium where each firm has an optimal position given the costs of maintaining ties. Firms will not shift their position anymore because there will be no opportunities left to strengthen their bridging position. Table 2-3 gives an overview of scholars who have made explicit assumptions about the available information about the network structure but who did not study the impact of this assumption. The two extremes (either complete or none information on network structure) may be necessary for analytical reasons but they rarely match with empirical reality. In reality, given limited resources available for environmental scanning (Peteraf & Bergen, 2003), it is likely that a firm only has information on a subset of the overall network structure. This information is what we refer to as a firm's *network horizon*[7].

> **Definition 19: network horizon:** the number of firms and their relationships that the focal firm (definition 7) knows to exist in an interfirm network (definition 1) as a percentage of the total number of firms and relationships in the interfirm network.

This definition excludes firms that the focal firm is aware of but the focal firm does not know how these firms are embedded in the overall network structure. The network horizon includes information includes who is connected with who, what changes, and when changes happen like creation of new ties or disbanding old ties.

In IS research it is common to distinguish three dimensions of the quality of information: 1) completeness, 2) timeliness, and 3) accurateness (Zmud, 1978). Our definition of network horizon is primarily focused on the completeness of information but timeliness and accurateness are important as well although we will not consider these two aspects explicitly in the remainder of this study. However, there are two arguments why we do not explicitly focus on timeliness and accurateness. First, one of the benefits of the bridging position is that information is received in a timely manner (Burt, 1992) thus the timeliness aspect of information is implicitly accounted for by our focus on bridging positions. Second, previous research on network cognition has demonstrated that individuals have difficulty in accurately interpreting information about the network structure (Casciaro, 1998; Krackhardt, 1990). Firms have more resources at their disposal compared with individuals for collecting, screening, and interpreting information that makes the risk of acting on inaccurate information smaller. Nevertheless, accuracy of

[7] The concept of network horizon was first coined by Anderson, Hakansson & Johanson (1994). These authors use the network horizon to delineate a firm's environment from the parts of its network that are relevant for decision-making.

information is an important topic and will be suggested as a theme for future research in Chapter 7.

Network horizon manifests itself at both the firm and network level. Heterogeneously distributed information about the network structure means that a firm enjoys a relative advantage rather than an absolute advantage in improving its network position. A focal firm's direct alters are not the only actors that can influence its network position, obviously other (non-alter) firms can do so as well but this depends on their network horizons. As argued previously, firms are likely to differ in their ability and efforts to collect information about their environment and the opportunities they recognize (Daft, Sormunen, & Parks, 1988; Denrell, Fang, & Winter, 2003; Makadok & Barney, 2001), i.e. different firms will have different network horizons. At the network level, this creates a distribution of network horizons over the different firms in the network, and this distribution determines the *network horizon heterogeneity* of the network.

Definition 21: network horizon heterogeneity: the interfirm differences in network horizon (definition 20) between firms.

2.7.3 Bridging positions are especially applicable to transaction networks

Previous research on the benefits of bridging positions has demonstrated that structural holes are generally not valuable when measuring performance in terms of the innovation output (Ahuja, 2000a; Obstfeld, 2005; Walker et al., 1997). Bridging ties and structural holes have been found to be especially valuable in transaction networks like, for example, investment banks syndicates (Baum, Rowley, & Shipilov, 2004; Baum et al., 2006), venture capital syndicates (Echols & Tsai, 2005) and the television industry (Soda et al., 2004). Walker et al. (1997: 188) suggest: "structural hole theory may apply more to networks of market transactions than to networks of cooperative relationships."

Hence, we choose bridging ties as the unit of analysis because we will conduct our research in the context of transaction networks (we will discuss this in more detail in Chapter 3).

2.7.4 Bridging positions are more dynamic than closed positions

We have distinguished between drivers of change and forces of inertia in the section about motivations for a firm to shift its network position. Previous research on closed network positions and cliques (Rowley et al., 2004; Rowley et al., 2005) has shown that cliques are remarkable stable over time. It is suggested that past and referral partnering (Gulati, 1995a; Uzzi, 1996) are partly responsible for the stability or inertia of this type of network position. This is in contrast with research on bridging positions that suggests that these positions are inherently more unstable (Burt, 2002). Thus, closed positions are often associated with network inertia and stability while bridging positions exhibit more dynamics. Therefore, the fourth reason to focus on bridging positions is that these positions are better suited to study network position dynamics.

2.8 Introduction Detailed Research Questions

So far, we have argued that bridging positions are an important source of value creation and that the interplay between drivers of change and forces of network inertia combined with the dominant network formation logic determine the probability that a firm will shift its network position. However, we have not yet dissected the overall research question into smaller sub questions. In this section, we will raise three detailed research questions that will be answered in Chapters 4, 5, and 6.

The dynamics of a network position refers to changes in a firm's network position. We distinguish quantitative and qualitative changes. A quantitative change means that the current network position of a firm either strengthens or weakens. For example, a firm occupying a bridging position establishes new bridging ties and thereby strengthens its current position. A qualitative change concerns the transformation of one type of network position to another type of network position. For example, a bridging position evolves to a closed position; or a peripheral position evolves towards a central position. A qualitative change of a network position means that how a firm creates value through its network position changes as well. Qualitative changes in network positions have not often been studied and we will address this issue in the future research section of Chapter 7. This study focuses on quantitative changes of network positions.

Based on the literature review of Section 2.3 we identify three types of quantitative dynamics of a network position. The drivers of network change can have two different repercussions for a network position of a firm: a network position can either strengthen or weaken. For example, if a firm performs above its aspiration level and therefore starts establishing new interfirm ties to access new sources of information then this firm is strengthening its network position. An example of the latter is when competitors are shifting their network position and thereby weakening the network position of the focal firm. The third type of dynamics is the absence of dynamics due to network inertia (as has been discussed in Section 2.4). Network inertia prevents a firm from shifting its network position.

Author(s)	Quotes about the importance of availability of information about potential partner firms
Van de Ven (1976: 31)	"Firms must be aware of possible sources in other agencies where their needed resources can be obtained; otherwise organizational directors are likely to conclude that the goal or need which motivates the search for resources cannot be attained. […] Awareness is therefore a predictor of the formation of inter-agency relations. […] This level of awareness identifies the number of potential alternatives for obtaining needed resources."
Gulati (1995b: 622)	"Discovering new alliance opportunities and finding an appropriate partner that desires an alliance requires very good access to market information. Firms need to know about the reliability of potential partners as well. Information thus has a twofold purpose: it makes firms aware of viable partners, and it serves as a basis for trust between partners. Firms can learn about potential alliance opportunities from many sources, and one important source is their network of prior alliances."
Uzzi (1997: 48)	"Embedded ties primarily develop out of third-party referral networks and previous personal relations. In these cases, one actor with an embedded tie to two unconnected actors acts as their 'go-between'."
Stuart (1998: 671)	"Because alliances are volitional relationships, a lack of access to a good set of willing exchange partners is a limitation on many firms' ability to put into place a productive cooperative strategy."
Gulati (1999: 399-400)	"For firms to build alliances… they must first be aware of the existence of potential partners."
Gulati & Gargiulo (1999: 1444)	"While interdependence may help a firm to orient the search for an adequate alliance partner, it cannot offer sufficient cues to determine with whom it should build such an alliance." "Yet, this approach masks the considerable heterogeneity of available information on prospective partners across firms, which may influence the formation of ties between specific firms…"
Rowley & Baum (2004: 120)	"The idea that managers are aware of their firms' networks and the types of positions that provide social capital advantages – core assumptions underpinning the network strategy perspective – remains largely unexplored."

Table 2-4 Quotes about the importance of information about the network structure

Summarizing, 1) a position can become stronger, 2) a position can be stable in strength (due to network inertia), and 3) a position can become weaker. Each of the detailed research questions focuses on one of these types of network position dynamics. Salancik (1995) argued that the field of network research should move beyond questions about the effects of network positions and raise questions that focus on why particular positions exist or do not exist in the first place. Salancik (1995: 349) phrased it as follows: "a more telling analysis might explain why the hole exists or why it was not filled before."

Having information about the network structure is an important prerequisite for a firm to be able to establish bridging ties. Surprisingly, there is a limited research about how much information a firm has about the network structure or what the consequences are of having information about the network structure although the importance of this type of information is acknowledged. Table 2-4 gives an overview for quotes about the importance of information about the network structure. Creating or strengthening a bridging position requires information about the network structure because without such information it is not possible to detect brokerage opportunities. Authors from Table 2-4, with the exception of Rowley and Baum, focus on the importance of 'being aware' of potential partner firms but this information of partner firms is conceptually distinct from having information about the network structure. Having information about a potential partner firm is sufficient to assess whether a firm has the needed capabilities, resources at an acceptable price and quality level. However, such a dyadic assessment of a potential partner firm ignores the impact this partnering decision can have on both the ego and global network structure and ignores potential leverage strategies by adding a new supplier that can potentially add information and control benefits. Thus, information about the network structure is required to move beyond a dyadic partner selection process but also to take into account the potential leverage strategies within the ego and across the global network. Thus, network horizon is not just the number of firms the focal firm has information about, but it is the level of completeness of information about the relationships between these firms. For example, the focal firm can be aware of ten potential partner firms but have no information about how these firms are connected (i.e. its network horizon is zero). The focal firm can still partner with any of these ten firms but it cannot make any assessment on how partnering with one of these firms will impact its own network position. Hence, this is a form of random partnering.

Some researchers have looked at the extent to which individuals are able to accurately map a network (Casciaro, 1998; Friedkin, 1983; Krackhardt, 1990) and generally found that individuals have limited resources and understanding of what the map of a network looks like and hence are poor in identifying brokerage opportunities. In contrast, firms do have the resources to monitor their environment and network and environmental scanning is one of the key activities a firm conducts (Hambrick, 1982). Thus, firms scanning their environment may be better able in detecting brokerage opportunities that in turn allows these firms to strengthen their bridging position. Therefore, the first detailed research question of this study concerns how firms capture and strengthen bridging positions:

Detailed Research Question 1: Why do bridging positions strengthen?

Now, we move our focus from the focal firm to the other firms in the network. Not just the focal firm is shifting its position but other firms in a network are doing the same. The literature on competitive dynamics shows that firms respond to each other's strategic actions (Chen, Su, & Tsai, 2007; Chen, 1996; Chen et al., 1992). We consider establishing an interfirm tie as a strategic action. The possibility for the focal firm to strengthen its bridging position becomes more limited as more firms are striving for the same bridging position. Sorensen and Ryall (2007) argue that the network position alone is rarely a sufficient condition for a firm to gain a sustainable competitive advantage. As the competition for these positions intensifies then it will be even harder for a firm to gain a sustainable competitive advantage from its network position. We get a more thorough understanding of why some bridging positions last longer than other bridging positions by incorporating the partnering behavior of all the firms in the network. Therefore, we raise our second detailed research question:

Detailed Research Question 2: Why do some bridging positions hold longer than other bridging positions?

We have argued that structural holes are potentially valuable spots in a network and that bridging positions unlock the value buried in these structural holes. However, if the structural holes are valuable then it means that the brokered firms have clear incentives either to reduce their dependence on the brokering firm, by establishing new ties or to connect directly to the firm possessing the required resources instead of relying on the brokering firm. This is consistent with the competitive dynamics (Chen et al., 2007; Chen, 1996; Chen et al., 1992) and resource dependence (Pfeffer & Salancik, 1978) view that firms will initiate actions to break away from a disadvantaged situation. Furthermore, there is evidence suggesting that bridging ties are short-lived. For example, Burt's study (2002) on bridging ties of managers showed that 90% of these ties disappear within a year. Hence, the third detailed research question concerns the actions bridged firms commence and the implications for the bridging position of the focal firm.

Detailed Research Question 3: Why do bridging positions weaken?

2.9 Summary

Figure 2-9 gives a schematic overview of how each of the three detailed research questions addresses a distinctive phase of the life cycle of a bridging position. Obviously, this process does not have to be linear, periods of strengthening can be followed by weakening, and a stable phase can be followed by a period of strengthening of the bridging position.

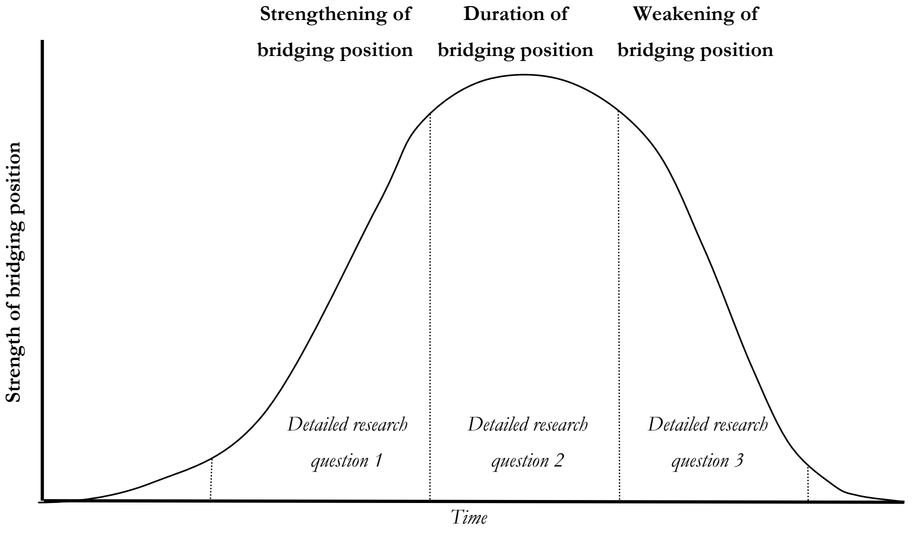


Figure 2-9 Detailed research questions cover distinctive phases of a bridging position

This chapter explained why interfirm networks emerge and how firms occupy positions within these networks that generate differential benefits to the firm in question. The impact of bridging and closed network positions on firm performance has been analyzed. We noted that networks are dynamic and hence these positions are rarely a stable source of competitive advantage. Studying network position dynamics has resulted in focusing on bridging position. Based on the research assumption that bridging positions are favorable network positions - the following are the key detailed research questions for this study: 1) why do bridging positions strengthen?, 2) why do some bridging positions hold longer than other bridging positions?, and 3) why do bridging positions weaken? Each of these questions has been researched following a multi-method and multi-level research approach as explained in Chapter 3. The outcome of each detailed research question will be presented as separate sub-studies in Chapter 4 (detailed research question 1); Chapter 5 (detailed research question 2) and Chapter 6 (detailed research question 3).

3 Research Methods and Data

This chapter[8,9] describes the empirical setting of our research and the three research methods we applied. Before we introduce our research methods, we will first introduce the Dutch insurance industry as empirical setting for and justify this context for conducting our research. Then, we move on to explain why we choose these three research methods. The three research methods we introduce in this chapter are network experiments, a computational model, and a field study. Hence, this chapter gives the methodological background of the research methods applied in Chapters 4, 5, and 6.

3.1 Justification of the Research Methods

In Chapter 2, we raised three detailed research questions. Why does a bridging position strengthen, why does a bridging position weaken and why do some bridging positions last longer than other bridging positions. We use three different research methods to collect the data to answer these questions. Using multiple methods is referred to as method triangulation (Mingers, 2001). Method triangulation is a research strategy that aims at compensating an inherent weakness of one method with the strength of another method. The research methods we are use are network experiments, computational modeling, and field data.

The study of network position dynamics requires longitudinal data with enough variance at the network position level in order to investigate the causal mechanisms that potentially explain why a bridging position changes. Furthermore, we want to link the decision-making process of organizational decision-makers to their decision of changing

[8] Parts of the developments in the Dutch insurance industry have been published in van Liere, D. W., Hagdorn, L., Hoogeweegen, M. R., & Vervest, P. H. M. 2004. Embedded Coordination in a Business Network. ***Journal of Information Technology***, 19(4): 261-269.

[9] The explanation of the network experiments has been published in Hoogeweegen, M. R., van Liere, D. W., Vervest, P. H. M., Hagdorn van der Meijden, L., & de Lepper, I. 2006. Strategizing for Mass Customization by Playing the Business Networking Game. ***Decision Support Systems***, 42(3): 1402-1412.

their network position. Collecting data about the partnering decisions raises two issues: 1) how to sample firms that are going to make such decisions while they are being studied and 2) whether firms are committed to support the research for a longer period in order to investigate the dynamics of a network position. Collecting longitudinal network data is a resource intensive process (Gibbons, 2004), especially when information about the individual firm decisions has to be collected on a recurring basis effectively ruling out case studies. This is further complicated by the network boundary specification problem (Laumann, Marsden, & Prensky, 1983). This problem relates to the question where to draw the boundary of the network, which firms belong or do not belong to the network. The network boundary specification problem is especially important when studying interfirm networks from a structural embeddedness perspective because how the boundary is drawn has implications for the network positions of firms. Inaccurately drawing the network boundary can underestimate or overestimate the importance of firms in the network. Network surveys have the limitation that collected network data is often inaccurate and incomplete (Marsden, 1990) because people have the tendency to report frequently used relationships because they remember those relationships better. This severely hampers the possibility of constructing reliable network structures.

Therefore, we chose to conduct network experiments as our first method because experiments allow a researcher to manipulate different circumstances and to link individual decisions to changing network positions. However, the network experiments have two limitations. First, the networks we used during the experiments were small and this could potentially limit the generalizability of our findings. Second, the external validity is a potential weakness of experiments (Shadish et al., 2002). How representative is the behavior from participants in an artificial setting compared with how firms behave in a real world situation?

In order to mitigate these two concerns, we will be using two additional research methods. Each method addresses one specific weakness of the network experiments. The second method is computational modeling. Using this method, we will be simulating the behavior of simplified firms in large networks. Simulation can be seen as a form of computerized experiments and therefore we will treat it as if it is an experiment. The third research method is a field study of the Dutch insurance network. The field data addresses the concern of limited generalizability from both the network experiments and simulation. Thus, we adopt three methods to study the three detailed research questions; this is an example of method triangulation.

Table 3-1 relates the three research questions with the three research methods. It is not possible to answer each research question with the three research methods due to data limitations. However, there are no fundamental reasons why these research questions cannot be addressed by these methods.

Research method / Research question	Network experiment	Computational modeling	Field data	Chapter
RQ1: Why does a bridging position strengthen?	✓	✓		4
RQ2: Why do some bridging positions last longer than other bridging positions?		✓		5
RQ3: Why does a bridging position weaken?	✓		✓	6

Table 3-1 Relationship between research methods and research questions

3.2 Generic Modeling of the Network Experiment

Modeling a network experiment means that we have to abstract a real life situation to a simplified model but that model should still capture the essence of a real life situation.

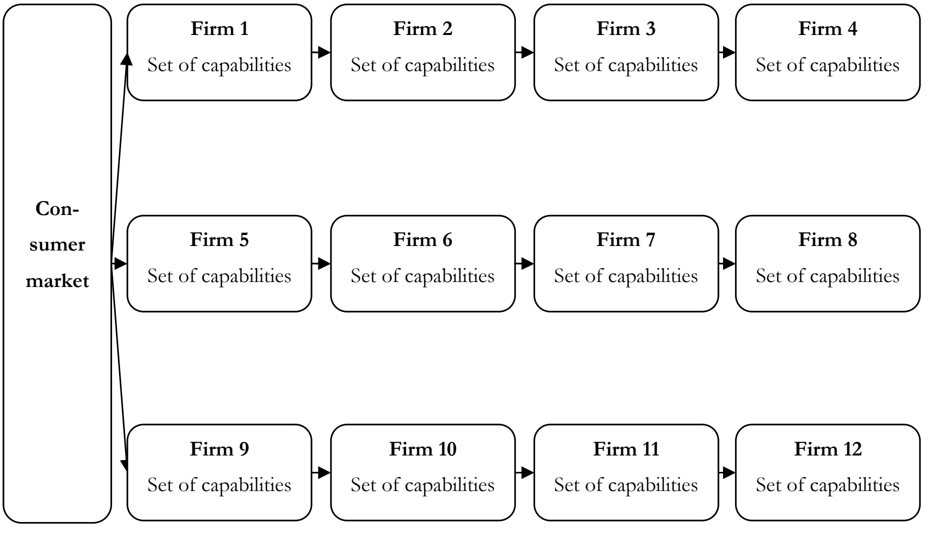


Figure 3-1 Generic model of the network experiment

Three important building blocks we use to model our network experiments are a firm, its capabilities (consistent with the definition of Amit and Schoemaker (1993) from Chapter 2) and its relationships. So far, these building blocks are context free. A firm has a set of capabilities and has some relationships. These firms are connected to each other in a simple chain network structure (consistent with definition 1 from Chapter 2). The capabilities that each firm possesses may be unique in the network but some capabilities will be redundant.

A basic premise of the network experiment is that the network position of a firm determines its access to capabilities and this determines how often a firm is needed for the production of a particular product. A firm that is more often needed to produce a particular product will increase its financial performance. This means that occupying a bridging position is beneficial for the financial performance of the firms in the network experiments. For example, in Figure 3-1 there are nine bridging positions (firms 1, 2, 3, 5, 6, 7, 9, 10, and 11 occupy a bridging position). An alternative route to increase a firm's performance is to specialize in a set of capabilities. This increases the attractiveness of the specialized firm as a potential partner because it can offer certain capabilities more attractively (in the experiment defined as "at a lower price") than other firms in the network can. Therefore, the specialized firm will be more sought after by other firms in the network.

The set of capabilities that a firm possesses at the start of an experiment determines its role in the network. In our network experiments, we assume that firms have a quick connect capability and are able to quickly establish or disband interfirm relationships (see Chapter 2). Although some firms may experience inertial forces that inhibit a firm to establish quickly a new interfirm relationship, there are two reasons why such a technical infrastructure may overcome some of these network inertia forces. First, modularization of a product reduces the uncertainty about the design specifications and therefore reduces the uncertainty associated with developing new products (Sanchez & Mahoney, 1996). Thus, market level uncertainty will be lower and hence makes it more likely that a firm will establish an interfirm relationship. Second, a technical infrastructure gains legitimacy as industry leaders adopt such an infrastructure. When prominent firms use such a new technology then other firms are more eager to adopt this technical infrastructure as well because the perceived uncertainty is reduced or larger firms create monetary incentives for smaller firms to adopt a quick-connect capability. In addition, we assume that in our network experiments firms have modularized their products (see

Chapter 2). Thus, the capabilities the firm possesses can be mixed and matched to create a customized product. These two assumptions allow a participant to change its role in the network or to stick to its original role. Finally, we developed three distinct strategies based on Treacy and Wiersema (1993) to condition the behavior of the participants and we will discuss this in more detail in section 3.4.4.

This generic model can be applied in different industries. The next section explains why we have chosen for the Dutch insurance industry to apply this generic model.

3.3 The Dutch Insurance Network as Empirical Background

CEO Bas de Voogd from Voogd & Voogd Verzekeringen (Voogd & Voogd, 2006) summarizes the transition the Dutch insurance industry is witnessing as follows:

"Thinking in chains has never attracted me as an entrepreneur. […] It assumes loyalty to a system of fixed, sequential elements that cannot exist independent of each other. We prefer to think in terms of networks in which highly qualified firms create standards that lead to optimal service level to both consumer and business customers."

The Dutch insurance industry is slowly transforming into a vertical network because of the technological and specialization developments that were described in the previous chapter. This transition makes the Dutch insurance industry an appropriate empirical setting for conducting our research. The insurance industry has been used as a context for studying interorganizational relationships in the past; examples include the work of Zaheer and Venkatraman (1994; 1995). Furthermore, insurance policies are not tangible products but rather it is an intangible service. Services cannot be stored in stock but are rendered on demand; this means that there is almost no logistical component involved in the production of a service. This makes it easier to use quick connect capabilities to connect to other firms because there is no physical flow of goods. In addition, a large Dutch insurance firm and a business process outsourcing firm have been willing to support and participate in this research. Three developments in particular are transforming the insurance industry into a vertical network, which will be discussed in the next three sections.

3.3.1 Standardization of communication and quick-connect capabilities

Insurance firms develop new insurance products, they market and brand them, they accept or reject customers, they handle claims, and they reinsure their risks with reinsurance firms. Insurance brokers focus on building personal relationships and advising their clients on matters of property insurance, life insurance, and mortgages. Insurance brokers are experiencing increased competition from direct writers and banks. Direct writers are insurance firms that sell their policies directly to the customer. Insurance firms and broker associations have joined hands to develop new standards that ease the communication between broker and insurance firm, reduce the number of errors, and reduce the lead-time between applying for a new policy and the final acceptation or rejection of the customer. Four standards have been developed (van Liere et al., 2004): 1) a standard for processes (Process Atlas), 2) a standard for data (All Finance Model), 3) a standard for transactions (GIM) and 4) a presentation standard. The Process Atlas describes the different processes that invoked during the advice and sales phases. The data standard describes how and which customer and insurance policy information is recorded. The transaction standard describes how data is communicated between a broker and an insurance firm. The presentation standard describes the layout of the data. These four standards are part of the chain integration project of SIVI. SIVI stands for Standardization Institute for Insurance Policies Sold through Insurance Brokers (Standaardisatie Instituut voor Verzekeringen in de Intermediairbranche[10]). Integration of the value chain is a means to improve the efficiency of the insurance sales process, to reduce the administrative burden and to make the brokers more competitive vis-à-vis the direct writers. SIVI is an industry body that developed and facilitates the implementation of these standards. Standardization of communication is an important prerequisite for interfirm specialization (Jacobides, 2005). Once these standards are implemented it becomes possible for insurance brokers to quickly connect and disconnect with insurance firms (Vervest et al., 2004).

[10] The website of SIVI can be found at www.sivi.org and it includes, among other things, the specification of the four standards.

3.3.2 Intrafirm partitioning and interfirm specialization

The second development is that intrafirm partitioning and interfirm specialization (Jacobides, 2005; Jacobides & Billinger, 2006) lead to different roles within the insurance industry. The increased standardization within the industry makes it possible for both insurance firms and insurance brokers to focus on a particular part of the value chain. Some brokers are becoming authorized resellers: they develop capabilities to maintain a customer administration themselves and to accept and reject customers. Some insurance firms are developing shared service centers that make it possible to simplify the back office and reuse processes across different product categories and different brands. While these shared service centers mainly handle internal customers, it is believed that soon these shared service centers will also handle external customers (i.e. competitors). Finally, some industry experts are predicting that the insurance broker will transform itself into a 'networked company' that maintains ties not only with insurance firms or underwriting agents but also with other brokers, real estate agents, notaries and ad-hoc experts (Telematica Instituut, 2006).

3.3.3 Horizontal alliances

The third development is that brokers are organizing themselves in horizontal broker alliances to increase their bargaining power vis-à-vis the insurance firms and to get access to insurance firms with whom they do not have a direct relationship themselves. Besides these horizontal broker alliances, there is also a steady increase of broker franchises. These broker franchises operate under a single brand and have standardized their administration processes. These franchises make it possible to conduct business with more insurance firms because of their economies of scale. These two trends lead to an increasing number of broker-to-broker relationships and thereby transforming the vertical insurance network into a horizontal network.

These three developments transform the Dutch insurance network. Standardization of communication, interfirm specialization, and horizontal broker alliances are transforming the vertical insurance network into a horizontal network. This justifies why we have chosen the insurance industry as the empirical background for conducting our research. Furthermore, the current transition means that the insurance network is dynamic and this gives enough variance in the data to explore the drivers of network position dynamics.

3.4 Research Method 1 – Network Experiments

What circumstances drive decision-makers to strengthen their bridging position? In order to investigate our first detailed research question we developed a network experiment environment. The network experiment environment, called the "The Business Networking Engine" (shortened to BNE), is a multi-player computer-based management game[11] developed by RSM Erasmus University in cooperation with A.T. Kearney. Participants play the role of an organizational decision-maker of a simulated firm and have the assignment that he/she should try to be the most profitable firm in the network in terms of margin and net income. The network experiments are built in such a way that bridging positions are beneficial for firm performance: the participants are unaware of this. Participants expanding their bridging positions are more likely to win an experiment.

We have simplified the firms in our network experiments. Each firm possesses two or three capabilities depending on its role in the business network. A customer market generates demand for insurance policies: this demand is defined as a specific set of capabilities. An order is awarded to a participant (i.e. one of the firms in the business network) if this participant firm can produce the required set of capabilities either by producing the set of capabilities itself, or by having access to such capabilities through its relationships in the business network (or a combination of firm capabilities and partner capabilities). None of the firms possesses the required capabilities to produce these insurance policies independently: they need to produce these policies jointly by way of establishing a relationship. Therefore, each firm needs to invest in a portfolio of interfirm relationships to access the required capabilities in the network. Once a firm has access to the capabilities that constitute an insurance policy then it will start receiving orders for that particular insurance policy and its profit will increase.

Each firm can also decide to invest in new capabilities or to specialize in existing capabilities. So three investment (and divestment) decisions impact if a participant firm will do better than others in the game: invest in / or divest interfirm relationships, invest in new capabilities, or invest in specializing existing capabilities, or divest existing capabilities. In essence, the two main levers to increase the financial performance of a

[11] The Business Network Engine is available at bne.rsm.nl and includes tutorials, software to evaluate a session and a tool to check the compatibility of the browser.

firm are either to invest / divest in new interfirm relationships or to invest / divest in capabilities.

3.4.1 Order allocation process

A simulated market generates each time unit (is defined in section 3.4.2) a demand defined as a collection of capabilities at a certain price. This collection of capabilities becomes an order when a firm has a relationship with the consumer market and is able to deliver the required capabilities. Either a firm can deliver these capabilities itself or it can establish relationships with other firms in the network that are able to deliver the required capabilities, or there can be a combination of these two possibilities. If multiple firms can deliver the required order then the firm who offers the lowest total price receives the order. If multiple firms offer the same price then a firm with the oldest relationship with the consumer market is chosen. If multiple firms have the same age for their relationship with the consumer market then a firm is randomly chosen. Thus, a firm receives an order if it can deliver the required capabilities and if it can do so at the lowest possible price. The demand is stable over time and the consumer market does not respond to changes in the network structure.

A role is based upon the capabilities a firm possesses at the start of a network experiment. The essence of the Business Network Engine is that participants of the firms can change their starting role by investing in new capabilities or in new interfirm relationships. The starting roles are insurance advice, sales, customer acceptation, service center, and customer service. There are different capabilities within each role. Table 3-2 summarizes which role each firm has at the start of an experiment and with which capabilities it starts. Firms at the start of an experiment do not offer capabilities in italics but participants can decide to invest in these capabilities. The number in parentheses behind the capability indicates the id number.

The network contains at the start of an experiment 15 firms and this number will stay fixed throughout the experiment. However, we also have a scenario of 14 firms. In this scenario, the firms Pluto and Hermes have been merged to one firm Hermes that possesses both the generic advice and product bronze capability. The reason was that due to space limitations it was not always possible to use 15 computers.

An order contains from each role one capability. This means that these thirteen unique capabilities can be combined into 36 different orders (2 * 3 * 3 * 2 = 36). The reason that there are only 36 unique orders and not 108 is because once an order has a customer acceptation capability then the accompanying service center capability is determined as well. Customer acceptation and service center capabilities are dependent on each other. For example, it is not possible to have an insurance policy with a car acceptation capability and a travel settlement capability. Figure 3-2 illustrates the initial distribution of capabilities and initial network structure.

Firms	**Roles**	**Capabilities**
Apollo	Insurance advice	Generic advice (1)
Jupiter		*Specific advice (2)*
Pluto		
Miracle	Sales	Product line bronze (3)
Diamond		*Product line silver (4)*
Hermes		*Product line gold (5)*
Archimedes	Customer acceptation	Accept car policy (6)
Blazer		Accept home policy (7)
Saturn		Accept travel policy (8)
Phoenix	Service center	Claims settlement car (9)
Rainbow		Claims settlement home (10)
Delphi		Claims settlement travel (11)
Crystal	Customer service	Customer care online (12)
Cosimo		*Customer care call center (13)*
Star		

Table 3-2 Relationship between firms – roles and capabilities

We have not modeled capacity constraints for the production of insurance policies in our experiments. Although firms clearly do have a capacity constraint, we think that in this particular context it is less relevant. The production of an insurance policy is fully automated, due to the embedded coordination of the quick connect capability (van Liere et al., 2004) and production times are measured in minutes or hours rather then weeks or months, and thus the daily production of insurance policies will always surpass the daily demand for insurance policies.

Thus, at the start of the experiment, 'network 1' can only fulfill insurance policies consisting of capabilities 1, 3, 6, 9, and 12. Likewise, 'network 2' can only fulfill insurance policies consisting of capabilities 1, 3, 7, 10, and 12 and 'network 3' can only fulfill insurance policies consisting of capabilities 1, 3, 8, 11, and 12.

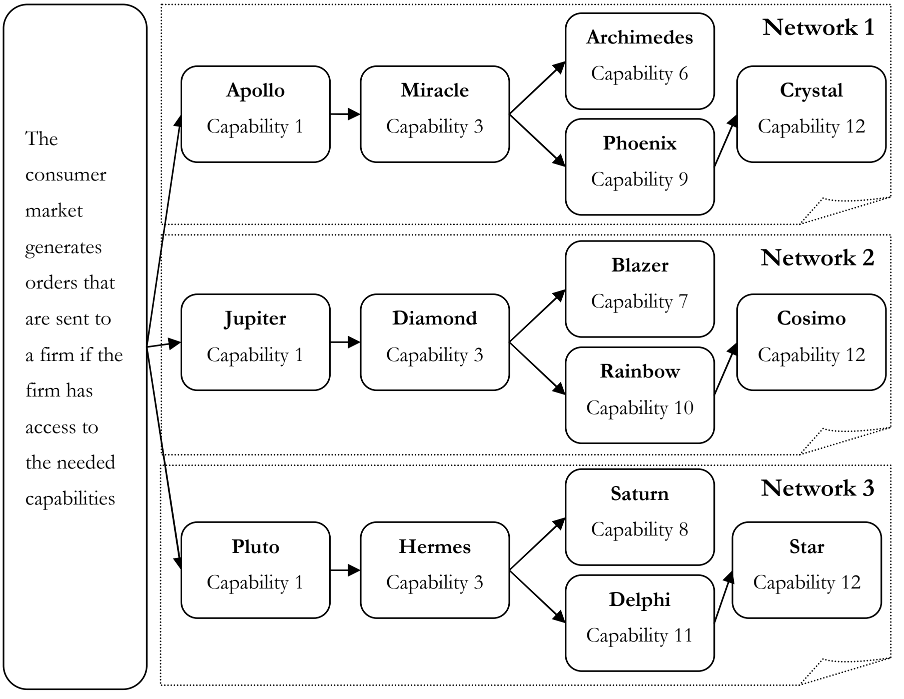


Figure 3-2 Initial network structure and distribution of the capabilities

This means that at the start of each experiment each network can only satisfy 1/36 of the total number of orders. The networks will be able to satisfy a wider range of orders as the number of offered capabilities in the network increases. When a firm is more often involved in the production of a particular insurance policy then it will increase its financial performance. The financial performance is measured with two metrics: net income (defined as turnover – fixed costs – variable costs) and gross margin (defined as $\frac{(fixed\ costs + variable\ costs)}{turnover} * 100\%$. Participants should score high on both metrics in order to become the winner of an experiment. How often a firm is part of the production depends on two factors: the capabilities it can access through a firm's network position and the capabilities a firm possesses itself. The consumer market generates customer orders for car, home, and travel insurance policies at a stable rate. An insurance policy is offered at three different levels: product line bronze, product line silver and product line gold. The insurance network consists of fourteen organizational units grouped into five separate roles and these roles are represented in the experiment as separate organizations. The three brokers ("Apollo", "Jupiter", and "Pluto") have direct access to the consumer market. These firms are the insurance brokers. Apollo is the insurance broker for the car insurance policies; Jupiter is the insurance broker for the home insurance policies and Pluto is the insurance broker for the travel policies. The second firm is called "Miracle" for the car insurance policies and "Diamond" for the home insurance policies and "Hermes" for the travel insurance policies and all three of them offer product line bronze. These three firms are responsible for the branding and marketing of the policies. The third firm is called "Phoenix" for the car insurance policies and "Rainbow" for the home insurance policies and "Saturn" for the travel insurance policies. They are responsible for the customer acceptation process, that is, screening a customer, assessing the risk of the customer and deciding whether the customer is accepted or not (in our experiments each customer is always accepted). The fourth firm is called "Archimedes" for the car insurance policies and "Blazer" for the home insurance policies and "Delphi" for the travel insurance policies. They are responsible for the settlement of all damage claims of insured customers. The fifth firm is called "Cosimo" for car insurance policies and "Crystal" for the home insurance policies and "Star" for the travel insurance policies, and they take care of all administrative processes of handling policies and offer customer service either by using a call center or a website.

3.4.2 Time sequencing

We have conducted pilot studies to examine how long an experiment should last and how much time we should give to the participants to process the information and make decisions. Furthermore, these pilot studies revealed that after a certain time the network converged to an end state without a lot of variance in the network positions of firms. Finally, there are time constraints on how long participants are willing to participate. Therefore, we decided that one experiment should last 43 time units (which equals to approximately 30 real-time minutes). Those 43 time units are divided in two different periods. An experiment starts with an information-gathering period that lasts seven time units. A participant can evaluate its current financial performance, evaluate past decisions, and formulate new decisions for the coming time units during an information-gathering period. An information-gathering period lasts for 3.5 real-time minutes. An information-gathering period is continued with a decision point. The decision point is used to execute actual decisions: an investment in a new interfirm tie can be made or a firm can divest capability or a new capability can be bought. A decision point lasts for two real-time minutes. An experiment consists of five information-gathering periods, five decision points and three time units to end the experiment. Figure 3-3 visualizes the structure of an experiment.

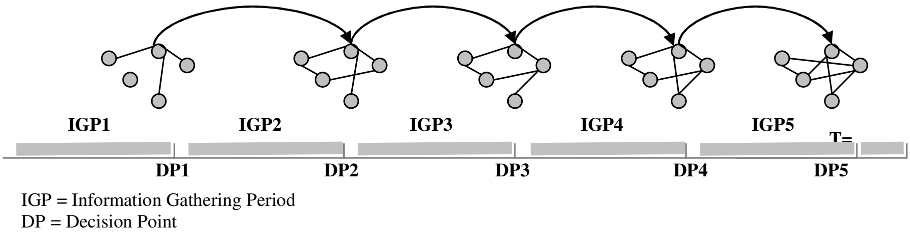


Figure 3-3 Sequence of information gathering periods and decision points

A participant can only make one investment during each decision point. This compels participants to envision the possible consequences of the different decisions they can take and to make the decision they think will improve their performance the most.

3.4.3 Managing a firm in the Business Network Engine

Each firm starts with an initial cash position to cover the initial fixed costs of the first time units, to pay for outsourced capabilities and to let participants invest in capabilities and relationships. For the purpose of the experiments, we set the initial cash position at €50.000. This money can be used to invest in a new interfirm relationship to increase the access to capabilities or to invest in a new capability or specializing an existing capability. There are costs associated with maintaining capabilities, these are so-called fixed costs and are deducted from the cash position at the end of each time unit. Specializing an existing capability means that a firms' fixed costs increase, but that the variable production costs are reduced. Hence, this investment makes sense when a firm has a significant market share for a particular capability it has specialized. Figure 3-4 illustrates the business network and the investment options to start or terminate a relationship. This screen, visualizing the network, is used to invest or divest interfirm relationships by clicking on the node with whom wants to connect. This representation of the network is consistent with Figure 3-2. Figure 3-5 shows the controls to invest in capabilities. Figure 3-6 shows how players are updated on their performance at the dyad level. Finally, Figure 3-7 gives an overall view of the performance of their firm. To give the participants some guidance in the actions to take, we have developed three distinct strategies.

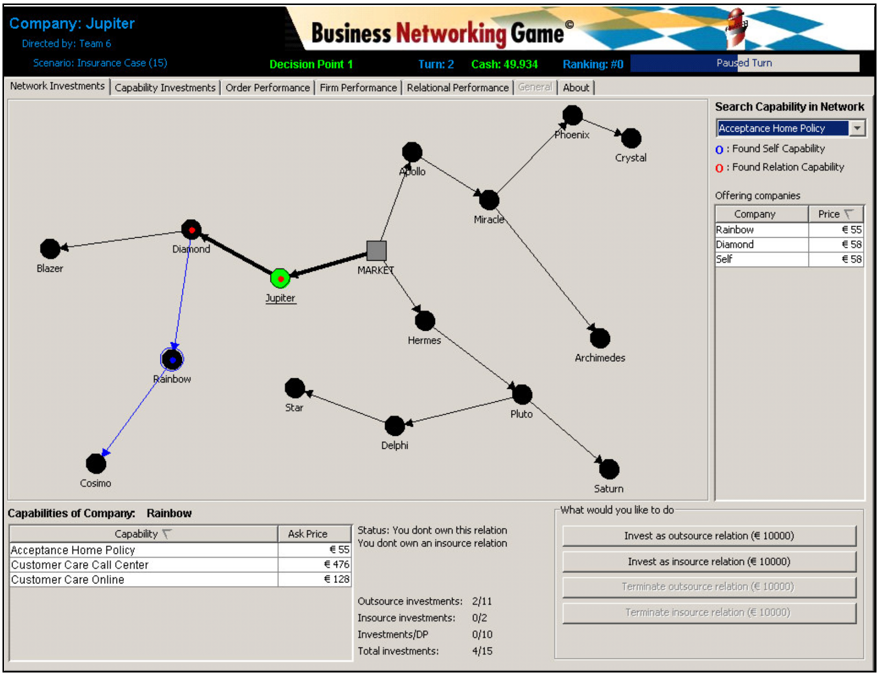


Figure 3-4 Screenshot network experiment investing in relationships

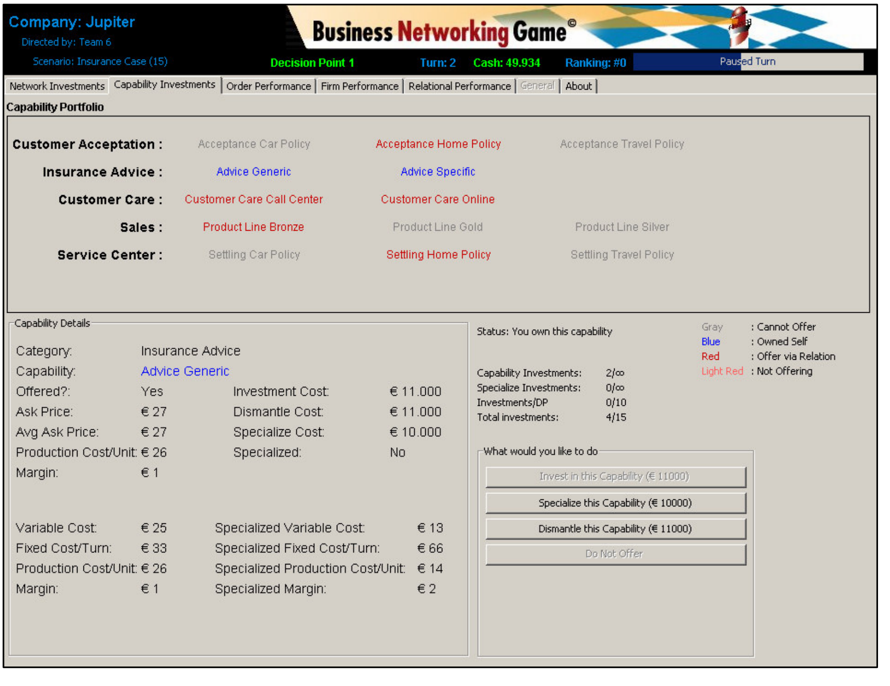


Figure 3-5 Screenshot network experiment investing in capabilities

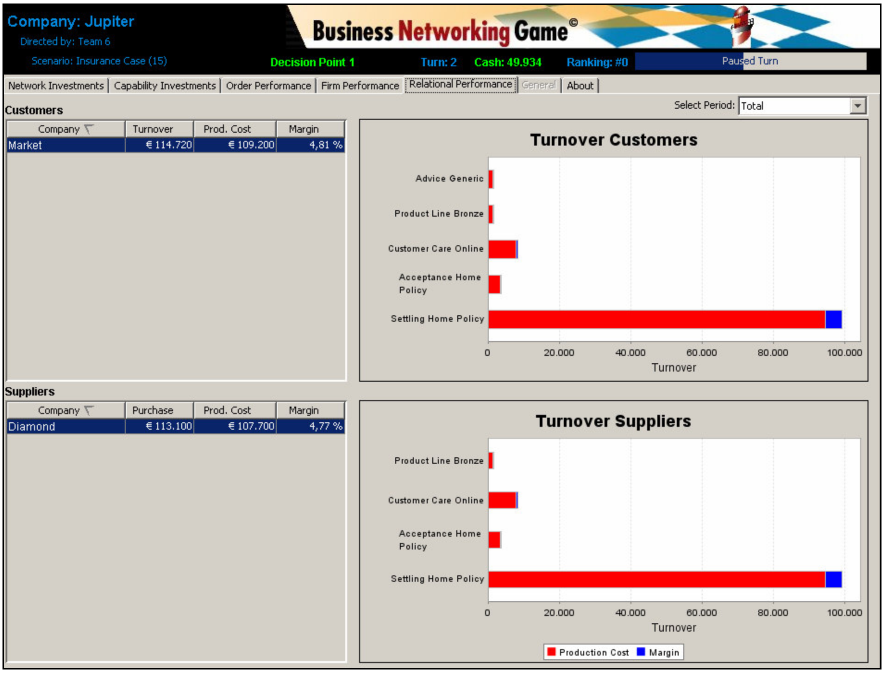


Figure 3-6 Screenshot network experiment monitoring performance of suppliers

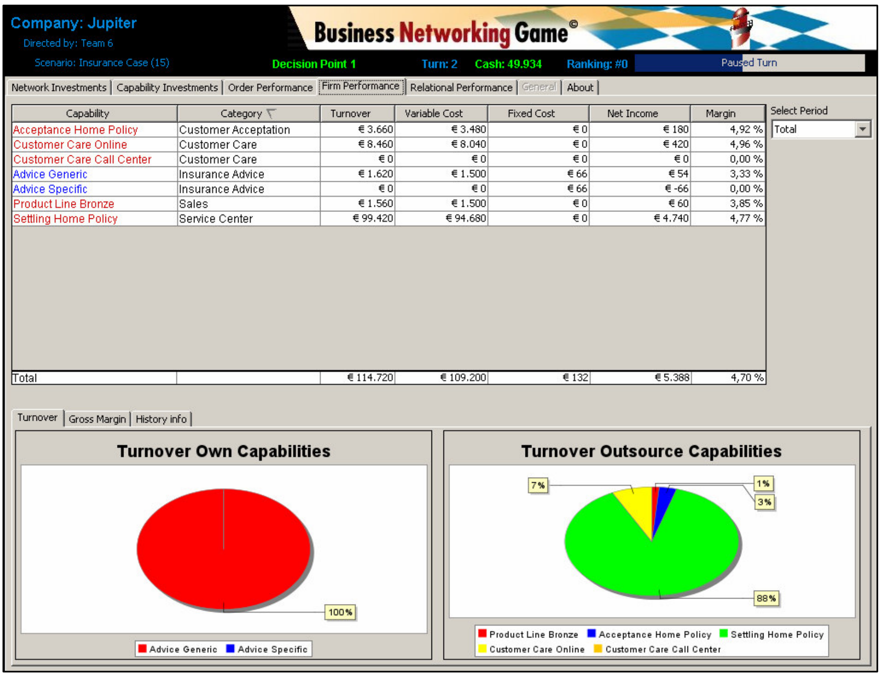


Figure 3-7 Screenshot network experiment monitoring performance of firm

3.4.4 Strategies to increase firm performance during the experiments

We use three strategies as defined by Treacy & Wiersema (1993) to assist participants in deciding how to run their simulated firm. Treacy & Wiersema (1993: 84) propose that organizations that have taken leadership positions within their industries or business networks have focused on "… delivering superior customer value in line with one of three value disciplines – operational excellence, customer intimacy, or product leadership". We chose for these three strategies because they can be easily operationalized in capabilities and network positions and these three strategies are well understood by both business administration students and insurance professionals. These strategies are randomly distributed among the participants at the start of an experiment but a participant keeps the same strategy card throughout the whole session.

Operational excellence refers to providing reliable products and services to customers against competitive prices and convenience. Customer intimacy refers to the ability to meet customized demand by tailoring production to the exact requirements of individual customers or market niches. Product leadership refers to the offering of innovative, leading-edge products and services to customers that enhance the use or application of the product or service; this should offset the value of the competitors' products and services.

All three strategies are potentially interesting in order to increase the financial firm performance. For instance, by specializing production, a firm could become a main node within the network and be part of virtually every temporary alignment formed within the network (operational excellence). Another focus could be to approach the end-customer and act as a "network coordinator" to fulfill its customized demand by forming the right temporary alignment (customer intimacy). Yet another option could be to innovate and develop new capabilities to meet the customers' demand for state-of-art products and services (product leadership).

These three strategies are written down on three different strategy cards and these strategy cards are randomly distributed among the participants of a network experiment.

3.4.5 Participants of the experiments

We used three groups of participants to conduct our experiments: middle managers of an insurance firm and their insurance brokers, business administration master students, and a fixed team of business administration master students who participated frequently.

The first group of participants is from a large Dutch insurance company. Dutch insurance companies are promoting the adoption of quick connect capabilities through SIVI (see section 3.3.1). In collaboration with a large Dutch insurance firm, it was decided to organize jointly workshops to explore the effect of these SIVI standards on the transformation of a vertical network into a horizontal network. These workshops were called the SIVI workshops and the results of these workshops will be presented in Chapters 4 and 6. The Business Network Engine played an important role during these workshops. On the one hand, the Business Network Engine was used to let managers and brokers experience the effect of quick-connect capabilities on their business. On the other hand, the Business Network Engine was used to collect data to investigate how participants make decisions when they are establishing a new interorganizational relationship.

The second group of participants consists of two groups of business administration students. First, there are students who participated in a minor about business networks as part of their masters in business administrations and second there were students that participated at an in-house business course at the same insurance firm.

The third group of participants was a team of fifteen students who participated on a regular basis. This group was used to study whether there are learning effects in shifting a firm's network position. Multiple replications with the same participants increases the internal validity of the research design (Shadish et al., 2002). If the same type of results are observed compared with participants that only participated once then it can be concluded that the one-time participants were not randomly more successful but that the experimental treatment had the intended effect.

3.4.6 Reliability and validation Business Network Engine

The insurance scenario has been developed in close cooperation with a strategy consultancy firm, industry experts, and board members of an insurance firm. We asked ninety-eight participants from seven different pilot tests to rate, using a Likert scale, the simulation game on various aspects of its modeling of the insurance industry and the network aspects. The participants of the pilot tests were senior and middle-level managers of Dutch insurance firm and insurance brokers of the same insurance firm.

Statement asked on a Likert scale from strongly disagree (1) to strongly agree (5)	**Mean**
The modeling of the insurance products in the Business Network Engine is realistic.	4.4
The modeling of the initial business network is realistic.	4.4
The Business Network Engine simulates convincingly a business network.	4.3
The modeling of the trade-off between internal production and outsourcing is realistic.	4.2
The Business Network Engine provides a valid learning experience about managing a business network.	4.6
I have confidence in the Business Network Engine results.	4.4

Table 3-3 Results validation Business Network Engine

The results indicate that the participants generally agree that the simulation game is realistic in both simulating the insurance industry (products and capabilities) and the insurance network structure and different roles that are needed to sell an insurance policy.

We conducted numerous tests to validate the Business Network Engine. First, we calibrated the insurance scenario by comparing manually calculated firm performance with the performance according to the Business Network Engine. This test was conducted to make sure there are no bugs in the software that could lead to flawed performance results. Second, we conducted numerous computer interface tests to investigate whether participants understood the user interface and whether presented information was unambiguous. The results of these tests led to improvements of the software that were subsequently tested again. Third, we conducted 'stress' tests to see investigate the stability and performance of the overall software environment. These tests led to a redesigned database structure that is more efficient in storing data and software that is more robust by incorporating exception handling.

3.4.7 Software design of the Business Network Engine

The Business Network Engine consists of five software components that jointly create the network experiment environment. The five components are the player client, the administrator client, the evaluation client, the simulation game and the scenario. The player client is the actual software component that participants use. The player client visualizes the network of firms, the current firm performance and provides the graphical user interface (GUI) (see Figures 3-4 to 3-7) to execute decisions such as investments in capabilities and relationships. The administrator client is used to configure and randomize the independent variables, to configure the order allocation process and the time and game play.

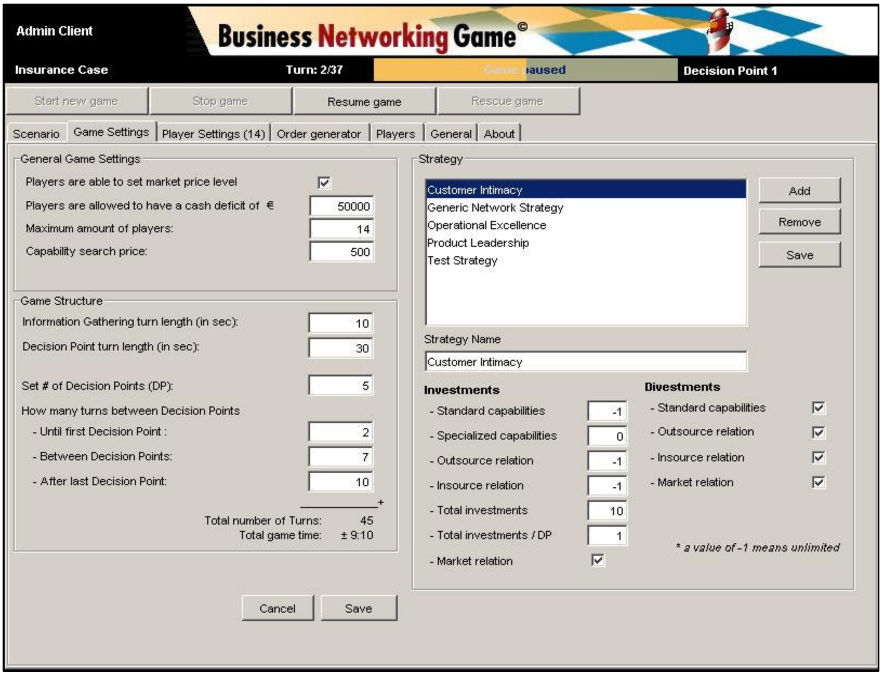


Figure 3-8 Screenshot from the administrator client to configure the experiments

The evaluation client is used to visualize the events that happened during an experiment and to give participants feedback on their performance and compare the performance across firms. The simulation Game receives its input from the administrator client and the various player clients, processes the inputs, and sends the outputs back to the player clients. The scenario determines the industry setting, which and many firms there are, which capabilities there are, the initial network structure and the costs of investing and maintaining relationships and capabilities. Because the scenario is adjustable, it means that the Business Network Engine can be easily customized and situated in different contexts. The software is built using Java and operates in a Java enabled Internet browser, and utilizes an Oracle database for data collection.

3.4.8 Design decisions and their implications for topics to be researched

A number of design decisions that were made while building the network experiment environment exclude a number of topics to be researched. These topics have become endogenous and therefore have become artifacts of the network experiment environment. Three design decisions are particularly important to mention. First, the network experiment environment is built around a transaction network and does not incorporate knowledge sharing, interfirm trust, or joint problem solving and therefore this network experiment environment cannot be used to research closed network positions or compare the relative benefits of bridging and closed network positions. Second, we modularized insurance policies into thirteen distinct capabilities. Modularization is an artifact of the network experiment environment and cannot be used as an independent variable to investigate what the optimal level of modularization is (Hoogeweegen & Vervest, 2004), whether modularization leads to improved firm performance and whether networks become more dynamic because of modularization. Third, the ability to connect quickly with other firms in the network is endogenously given. This means that we cannot investigate the impact of quick-connect capabilities on firm performance, how quick-connect capabilities should be implemented or the benefits and disadvantages of quick-connect capabilities. Thus, the fact that we explicitly focused on transaction networks, modularization of products and the existence of quick-connect capabilities exclude some topics to be addressed as we will discuss in the next section.

3.4.9 Limitations of the Business Network Engine

Four important limitations of the Business Network Engine have to be addressed. First, the network size is limited. The scenario we use consists of fourteen firms. Such a small network size limits the diversity of network positions and means that a network will soon find an equilibrium if each participant is trying to optimize its network position.

Second, we go at great length to make sure that participants understand how the experimental setting functions. However, some participants will have a better grasp of how to improve their firm performance and have a better understanding of what it means to operate in a network environment. We control for such differences in the empirical chapters but we do want to replicate these findings with artificial actors where such differences do not play a role. These two reasons combined are the justification for building a computational model to replicate the findings of the network experiments.

Third, a participant of a network experiment cannot reject the creation of a link when it is proposed. Nevertheless, a participant can terminate the link during the next decision point. This means that the network position of a firm can change without the consent of a participant. However, such changes in the network position will not often affect the firm performance negatively. If a firm creates an outsource relationship with the focal firm then this means that the focal firm has an extra customer who generate extra turnover. If a firm creates an insource relationship then it means that the focal firm has an extra supplier that can be used to reduce its procurement costs. The bridging position of the focal firm may weaken but if a participant understands the value of its bridging position then it is likely that such a relationship will be terminated. Although this modeling might not reflect practice, it is often used in research on network formation (Bala & Goyal, 2000) and we do not think, because of the abovementioned reasons, that it has material consequences for our research.

Fourth, experiments have as their major strength the ability to establish causality through randomization of the treatment and control over the environment (Shadish et al., 2002). However, the price of these strengths is that the external validity (i.e. how generalizable are the findings to an empirical setting) is limited. Limited generalizability of the network experiments is the justification to collect field data and to replicate partly the findings of the network experiments. See also Table 3-1 how the different research methods overlap or complement each other.

3.5 Research Method 2 – Computational Modeling

In contrast to using human subjects for our first research method, we use artificial subjects (i.e. agents) for our second research method. This second research method is similar to our network experiments except that in this case, we use artificial subjects and firms are homogenous (i.e. firms do not possess capabilities as in the network experiments). We developed a simulation tool called LINKS[12], acronym for Large Interfirm Network Simulator. Agents are autonomous entities in a software environment that perceive and act upon their environment (Wooldridge, 2000). An individual agent can be described using the 'beliefs-desire-intentions' model (Bratman, 1987). According to this system, an agent is modeled to have some information about its environment (beliefs), an agent pursues a certain state (desire), and an agent has a repertoire of actions (intentions) it can take to try to realize its desire. In our

[12] A detailed report on the design and development, including source code, and a working copy of LINKS are available at dep01-server02.fbk.eur.nl:8100. Parts of the source code have been released as part of the Java Universal Network Graph (JUNG) (jung.sourceforge.net) open source visualization project.

computational model, we modeled firms as agents. Each firm has a network horizon as its belief, the network position it pursues is its desire and the ability to form or terminate relationships are its intentions.

3.5.1 Software design of LINKS

A network in LINKS consists of nodes, which are firms, and the relations between the firms called edges. Each firm has a module (partner selection module) which determines the set of firms that the focal firm will consider as potential partners. Once the potential partners have been selected, the action selection module uses the utility function and capabilities of the firm to determine which capability-partner combination yields the highest utility. That capability is executed and as a result, an edge is created, deleted, or kept. This process is visualized in Figure 3-9.

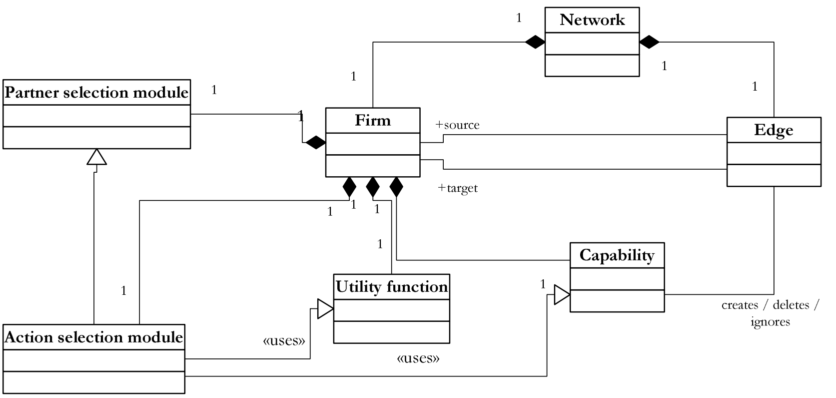


Figure 3-9 Simplified class diagram of LINKS

Building a computational model involves making design decisions that have implications for how the model will behave. We highlight the most important design decisions and explain why we have taken them.

First, the computational model is based on a cooperative network formation assumption (Watts, 2001) that requires that a link is only established when both actors agree. Severing a relationship remains a unilateral decision. We decided to build LINKS based upon a cooperative network assumption because this is more similar to how firms in a real world situation behave. This is contrast with the network experiments, which are a form of non-cooperative network formation (Bala & Goyal, 2000) which means that an actor can unilaterally decide to establish or sever a relationship.

Second, each actor in the computational model is homogenous. An actor does not possess any resources but they are identical. We control for firm differences that might explain why some bridging positions last longer than other bridging positions by making actors homogenous. The only reason for a simulated firm to establish a tie is to improve its network position. In practice, there will be multiple motivations to shift a network position but for analytical reasons we make the actors homogenous. A possible implication is that we overestimate the effect size of network horizon because in practice shifting a network position involves multiple motivations, one of which is possibly the network horizon. However, by controlling for firm factors that possibly influence the dynamics of network positions, we get a more detailed understanding of how network horizon and network horizon heterogeneity affect the dynamics of network positions.

Third, a relationship that is created is a directed tie (a directed tie is not necessarily reciprocated) and thus the networks we simulate are directed as well. A directed network has implications for the structural properties of a network compared with an undirected network. A directed network leads to greater differences between network positions and this gives us a better understanding of how bridging positions develop and why they do or do not last.

Fourth, during each cycle of the simulation a firm can initiate only one action. For example, suppose that Firm A has proposed to establish a relationship with firm B and firm B declines then firm A cannot propose another relationship with another firm. It will have to wait until the next cycle to propose to another firm. If we would allow a firm to make multiple partnering decisions during a cycle then this would imply that a network evolves quicker to an equilibrium and would make it harder to disentangle the causal mechanisms responsible for the dynamics of a network position due to the time compression. Therefore, allowing a firm to make one decision each cycle will not materially affect our results but will make it easier to analyze the results.

Fifth, we use a maximizing algorithm in the current set up of the experiment. This means that a firm will calculate for each firm in its network horizon how it would strengthen its bridging position if it established a relationship. A satisficing algorithm would only approach a certain portion of the firms in its network horizon to decide with whom to establish a relationship. Such an algorithm would lead to more variation in the dynamics of network positions because of the randomness of selecting a portion of the firms to approach for establish a tie. This variation is not attributable to network horizon or network horizon heterogeneity and we want to control for this extra explanation of network position dynamics.

3.5.2 Validation of the computational model

Empirical interfirm networks are often characterized by the fact that they are very sparse yet exhibit moderate to high levels of clustering and have low average path lengths (Baum et al., 2003). The simulated networks do exhibit this property as well; the average density[13] is 3.40%. Furthermore, the characteristic path length[14] is short (on average 3.05 links) while the cluster coefficient[15] is moderate (25.24%). This suggests that our simulated networks exhibit both local clustering and short path lengths that are characteristic for interfirm networks (Baum et al., 2003). Furthermore, some networks consist of hubs as is evidenced by the maximum observed degree centrality[16] of 46, however these hubs do not often dominate our network structures since the betweenness[17,18] and degree centralizations are low (4.7% and 14.2% respectively). Betweenness and degree centralization are measures that indicate to what extent a network structure is 'star' shaped, high values indicate a star shape. Finally, the standard deviations are small suggesting that the partnering algorithm is robust. Summarizing, our

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[13] Density is calculated as: $\frac{\sum x_{ij}}{n(n-1)}, i \neq j$ where x_{ij} represents the value of a relationship between *i* and *j* (assuming that x_{ij} only takes values of 0 or 1) and n is the number of nodes in the network.

[14] Characteristic path length is calculated by averaging the minimum path lengths among all nodes.

[15] Cluster coefficient is calculated as: $\frac{\sum x_{ij}}{k(k-1)}, i \neq j$ where k denotes the partners of the focal node and x_{ij} measures the strength between partners *j* and *k*. This fraction is then averaged among all nodes in the network.

[16] Degree centrality is calculated as: $\sum_i x_{ij} + x_{ji}$ or just the sum of relationships a node maintains. Degree centralization is calculated by summing this fraction and then dividing by the highest observed degree centrality.

[17] Betweenness centrality is calculated as: $\sum_i \sum_j \frac{g_{ikj}}{g_{ij}}, i \neq j \neq k$ g_{ij} is the number of geodesic paths from *i* to *j*, g_{ikj} is the number of geodesic paths that pass along *k* and a geodesic path is the shortest path connecting two nodes in a network. The sum of this fraction is divided by the highest observed betweenness centrality to calculate the betweenness centralization.

simulated networks are sparse, exhibit both local clustering and relatively short path lengths. Therefore, we conclude that our computational model represents interfirm networks that are consistent with empirical interfirm networks. Table 3-4 shows descriptives of the key variables of the computational model.

Variable (network size is 100 firms)	**Number of ob-servations**[19]	**Mean**	**S.D.**	**95% Confidence interval**		**Min.**	**Max.**
Density[20]	390	0.0340	0.0210	-0.008[21]	0.0760	0	0.0969
Cluster coefficient[6]	390	0.2524	0.1220	0.0084	0.4964	0	0.75
Betweenness centralization[6]	390	0.0466	0.0343	-0.0220[7]	0.1152	0	0.1620
Degree centralization[6]	390	0.1415	0.0685	0.0044	0.2786	0	0.2723
Characteristic path length[22]	390	3.0514	0.7960	1.4595	4.6433	1	6.2329
Network horizon heterogeneity	390	0.3786	0.1473	0.0840	0.6732	0	0.7312
Degree centrality[8]	39000	6.7949	6.0370	-5.2791[7]	18.8689	0	46
Effective size[8]	39000	6.0411	5.1994	-4.3577[7]	16.4399	0	42.7391
Network horizon[23]	39000	10.2404	11.7277	-13.215[7]	33.6958	1	99[24]
Utility[9]	39000	2.0853	1.0690	-0.0527[7]	4.2232	0	6.4997

Table 3-4 Calibration of the computational model

3.6 Research Method 3 – Field Study

We collected archival data to construct the evolution of the Dutch insurance network to test our hypotheses regarding the strengthening and weakening of bridging positions. We obtained data from ABZ from their Assurantie Data Netwerk translated as

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[18] These measures are taken from Wasserman & Faust (1994).

[19] The number of observations for network level variables is: 15 experimental runs * 26 observation points = 390 and for firm level variables: 15 experimental runs * 26 observation points * 100 firms = 39000.

[20] These values should be interpreted as a percentage (observed value * 100).

[21] These values cannot be negative as is indicated by the minimal observed value.

[22] These values should be interpreted as a number of relationships.

[23] This value should be interpreted as the number of firms.

[24] The maximum number of firms a firm can have information about is n-1 where n is the number of nodes (firms) in the network.

Insurance Data Network (ADN). The AND is an electronic network that is used for communication between brokers and insurance firms. The ADN data consists of day-to-day transactions between insurance firms and brokers. Transactions include the prolongation of insurance policies and the applications for policies by new customers. We built a Java tool to process the data to build the database. The original ADN data consisted of 48 CD-ROM's containing zipped ASCII[25] EDI[26] messages, which totals approximately 312 GB of compressed data[27].

Next, we collected data from the SER (Social Economic Council) who administrates a database of the registered brokers and insurance firms in the Netherlands for the years 2002 - 2005. We obtained from a leading Dutch trade publication the 'Captive Guide' for the years 2003 and 2004. The Insurance Magazine is an independent industry journal that weekly informs its subscribers about trends and news in the insurance industry. The Captive Guide is a yearly publication aimed at increasing transparency in the insurance industry by making publicly available which brokers are (partially) owned by insurance firms. Information about the overall industry was obtained from the Verbond van Verzekeraars (Dutch Association of Insurers) and their annual publication; we collected data from this source for the period 1996 – 2005. The Dutch Association of Insurers represents "the interests of private insurance companies operating in the Netherlands. The Association's members represent more than 95 percent of the insurance market expressed in terms of gross premium income" (Verbond van Verzekeraars, 2005: 2). From the Dutch Association of Authorized Resellers (NVGA) we obtained a list of brokers that acts as an authorized reseller and which insurance firms they represent. From publisher Nijgh we obtained the VVP Adresdisc containing information regarding the brokers such as firm size, number of employees, diversity in product range, and chamber of commerce number. The database REACH provided us with financial performance data for the period 2000 – 2005. Finally, from the GRC Database Information Company we obtained the geo-code information to convert zip codes into longitudes and latitudes needed to construct the resource

[25] ASCII is the acronym for American Standard Code for Information Interchange and is the standard for character representation in computers; it is commonly referred to as 'plain text'.

[26] EDI is the acronym for Electronic Data Interchange and is a set of standards for structuring information to be electronically exchanged between companies.

[27] Manageable is an understatement: building this database took over a year of full time processing power of a dedicated server.

similarity variable. These data sources combined allowed us to construct a comprehensive database of the Dutch insurance industry that contains the network structure for the period 2002 – 2005 along with financial performance measures and descriptive variables of the individual firms.

Because of the sheer volume of the data, we choose to import only specific variables into the database. The variables that we imported can be divided in two categories: 1) network data, describing which firm conducts transactions with which other firm and 2) firm level variables describing the firm. We anonymized the data to ensure confidentiality. The Java tool was used to parse each EDI message, read the appropriate variables, and write them in the database. Processing 48 CD-ROM's into an SQL database took approximately three months continuously. This processing of this data resulted in a four-year day-to-day database of the interfirm network between insurance brokers and insurance firms. We aggregated this day-to-day data into years to make the database manageable. The yearly data was used to calculate the variables as is described in Chapter 6.

3.7 Summary

This chapter introduced three research methods. First, we introduced a network experiment environment to investigate why the bridging position of a firm strengthens. Second, we introduced a computational model to investigate both why the bridging position of a firm strengthens and why some bridging positions last longer than other bridging position. Our third research method is a field study that we use to investigate why a bridging position weakens. The following three chapters are three studies; each chapter addresses a detailed research question.

4 Strengthening of Bridging Positions: Network Horizon and Network Horizon Heterogeneity

Research on the benefits of structural holes is extensive. A firm occupying a bridging position enjoys information and control benefits, through spanning structural holes, that are beneficial for firm performance and create a network-based competitive advantage (Burt, 1992; Burt, 1997; 2000; McEvily & Zaheer, 1999; Walker et al., 1997). However, small world research suggests that interfirm networks are often characterized by dense cliques and bridging ties between those cliques (Baum et al., 2003) and therefore that some firms have more bridging ties (span more structural holes) than other firms do. In this chapter[28, 29], we propose an information-based view to explain why some firms span more structural holes than other firms do (which is based on Chapter 2). This information-based view is based on two key constructs: 1) network horizon, which refers to the completeness of information a firm has about the network structure, and 2) network horizon heterogeneity that refers to the distribution of information among the different firms in the network.

Understanding why some firms span more structural holes than others is important for three reasons. One, it will lead to insight of the dynamics of network positions. A network position is not a static given (Madhavan et al., 1998), rather it is the result of a firm's partnering decisions and the subsequent counter actions from its competitors. Gulati et al. (2000: 210) observed that "the ties formed or disbanded by any actor influence not only their own behavior in subsequent periods but also those of others to whom the actor is connected. One actor forms an alliance. Others match this

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[28] A previous version of this chapter was presented at the Academy of Management conference 2005 by van Liere, D. W., & Koppius, O. R. 2005. ***Network Horizon and the Creation of Structural Holes***. Paper presented at the Academy of Management Honolulu, HI.

[29] This chapter will appear in van Liere, D. W., Koppius, O. R., & Vervest, P. H. M. 2008. Network Horizon and the Sustainability of Network-Based Competitive Advantage. In J. A. C. Baum, & T. J. Rowley (Eds.), ***Advances in Strategic Management (Network Strategy)***, Vol. 25: JAI/Elsevier.

action." At the network level, we observe changes of the network structure, but we have limited understanding of how these changes are enacted by individual firms that try to improve their network position.

Second, it can answer the question how structural the advantage is that a broker will enjoy. Recent research suggests that brokers can attain a competitive advantage purely based on their network position only in strict circumstances (Sorenson & Ryall, 2007) and temporarily (Burt, 2002).

Third, previous research on network positions has predominantly focused on the consequences and in particular on the performance enhancing benefits of network positions. However, less research has focused on the antecedents of a particular network position. The call of Salancik (1995) to explain where structural holes come from is a call to study the antecedents of structural holes.

The remainder of this chapter is organized as follows. First, we argue that firms differ in how much information they possess about the network structure. Next, we introduce the network horizon and network horizon heterogeneity constructs and accompanying hypotheses. Subsequently, we first introduce the network experiments and results, next we introduce the computational modeling approach, results, and finally we conclude with a discussion and future research.

4.1 Firms Have Different Maps of the Interfirm Network

Network scholars recognize the importance of having information about potential partner firms and the overall network structure. Even though the notion of having information about the network structure is often acknowledged, it has received little empirical attention. Table 2-3 and Table 2-4 give an overview of the prevalence and importance of this assumption in the current interfirm network literature.

Baum and Rowley (2004: 120) phrase it as follows: "The idea that managers are aware of their firms' networks and the types of positions that provide social capital advantages – core assumptions underpinning the network strategy perspective – remains largely unexplored". Both versions of the information assumption (complete and incomplete) seem to be strong assumptions. We will focus in particular on interfirm information differences and how this affects the ability of a firm to shift its network position. It is important to note that information about the network structure has two properties: the extent to which information is *complete* and the extent to which the available information is *accurate*[30]. The completeness of information is important for the information processing view and resource-based view, the accuracy of information is important from a cognitive decision-making perspective.

The information processing view states that the acquisition and distribution of information within an organization is a key organizational activity (Daft & Weick, 1984). The organizational boundary functions as a filter of the information that comes to the attention of the firm. Even if information circulated freely, it would not always penetrate through the organizational boundaries because it is too costly to analyze all the available information. Pfeffer and Salancik (1978: 74) observed: "There is a great deal of information, but only some of this comes to the attention of the organization and is, therefore, relevant for understanding its behavior". The information that does come to the attention of the firm is usually the result environmental scanning and competitor analysis although this will be rarely complete or accurate (Sutcliffe, 1994).

Relationships are often invisible and information about relationships may be unavailable or incomplete. Most relationships are not announced publicly, large alliance and joint venture relationships are few of the exceptions. Instead, relationships are developed over time with no need to broadcast the existence of the relationship, or the existence of a relationship is kept low profile to minimize the risk of competitive signaling (Moore, 1992). A firm can detect relationships that are not publicly announced through observation and environmental scanning but this requires resources that are limited and costly. Or as Gulati, Nohria & Zaheer (2000: 208) phrase it "the private and

[30] On page 51, we acknowledged three dimensions of the quality of information: completeness, timeliness, and accurateness. It is important to note that the network itself is a valuable source of information about network members especially because it gives timely and accurate information (Gulati and Gargiulo, 1999; Xi and Rowley, 2002). Most information about changes in the network structure is not publicly announced; high profile interfirm relationships such as alliances and joint ventures are exceptions. However, before this type of information becomes public, it might already circulate privately in the network as confidential information or as a rumor. Bridging positions are most likely to pick up these types of information because they span diverse unconnected groups of firms. Information is more accurate when the same information is received from different sources (triangulation of information). The network becomes even more important when a firm wants to obtain information about the dissolution of interfirm relationships. While marriages are announced and celebrated (establishing an important interfirm relationship), the divorce (dissolution of an interfirm relationship) is kept quiet and the same is true for firms; for an exception see Jensen (2006). To obtain this kind of information, the most reliable source for a firm is to turn to its partner firms.

invisible nature of the ties renders the network inimitable, and thus too the information that it provides".

The resource-based view stresses firm heterogeneity that contradicts both assumptions (complete information and no information) that firms are homogenous in how knowledgeable they are about the network structure. An important characteristic of firms is that they differ in their resources available to them; this difference in available resources is likely to translate into different levels of completeness of information about the network structure. For example, a firm may spend more or less resources on monitoring the environment compared with other firms in the network. Second, the current network position a firm occupies is a network resource (Gulati, 1999) that acts as a source of information about possible future partners (Uzzi, 1997). The idiosyncratic process that has lead to a particular network position is most likely to lead to differences in information about the network structure.

Research on cognitive decision-making processes has shown that individuals have a bounded perception of their environment and it seems too strong an assumption that firms are completely knowledgeable or uninformed about the network structure. Krackhardt (1990) demonstrated that managers occupying central positions in an organization have more accurate maps of the network structure than peripheral members. This stream of literature focuses on situational and personal factors that influence the ability of an individual to perceive the network accurately. For example, Casciaro (1998) finds that personality characteristics such as need for affiliation and need for achievement positively influences the perception of the network structure while a situational factor such as being part-time employed negatively influences the perception of the network structure.

Summarizing, based upon information processing theory, the resource based view, and cognitive decision-making we conclude that firms differ in their information about the network structure.

4.2 Network Horizon

Purposeful shifting of a network position requires that a firm has information about the network structure. A firm that only knows (randomly) of the existence of a potential partner but does not know how this firm is embedded in the overall network cannot accurately assess how partnering with that firm will influence its network position. One of the sources firms use to gather information about the network is to use their network position to gather information about the network structure. Information about the network is a network resource (Gulati, 1999), the information is scattered among partner firms and the partners' partner firms. In Chapter 2, we introduced the network horizon construct and defined it as "the number of firms and their relationships that the focal firm knows to exist in an interfirm network as a percentage of the total number of firms and relationships in the interfirm network". The better the firm is in gathering information about the network structure, the more aware it will be of valuable network positions. The current network position of a firm is an important determinant of the network horizon because the network position is an important source of new and novel information (Burt, 1992; Reagans & McEvily, 2003).

Network horizon is distinct from previous work on network perception (Freeman, 1992). Network horizon is a construct that captures the *completeness* of information about the network structure while network perception focuses on the extent to which an individual is able to map *accurately* the existing network structure. In the remainder of this dissertation, we will focus on the effect of completeness of information about the network structure. Inaccurate information about the network structure is most likely to be not aware of a relationship while in fact it does exist. The other way around, thinking that a relationship exist while in fact it does not is less likely to happen because this requires distorted information that is at least semi-private. However, if a firm makes a partnering decision based upon inaccurate information about the network structure then this information will be updated after the relationship has been established and this information will be updated to accurate information. The consequence of such partnering action is that the expected benefits of the network position are smaller than the actual benefits of the network position. Concluding, we acknowledge the importance of information accuracy but it is outside the scope of this study.

The network horizon construct resembles Friedkin's notion of *horizon of observability* (1983). The horizon of observability is reached when observability approaches zero, e.g. an individual does not have any information beyond the horizon of observability. Friedkin (1983) observed in the context of informal control of role performance that the horizon of observability is generally two steps. Consider a chain of four nodes (A-B-C-D) then A can monitor B and C but cannot monitor D. Anderson et al. (1994) used network horizon to delineate the business network from the environment, firms that fall within the network horizon are deemed to be relevant for managers' decision-making while firms that fall outside the network horizon belong to the environment. This is consistent with the definition of network horizon, the firms that are part of the network horizon are being monitored or have gained the attention of the firm, and hence this information is part of the decision-making process.

4.3 Network Horizon Heterogeneity

While each firm has a network horizon, this network horizon is not equal for each firm. Private or sensitive information does not flow freely through the network[31]; rather it might be shared between close partners or partner's partners. Two aspects of information availability are important, first there is the information distribution (Moldoveanu et al., 2003). What information about the network structure is available to which firm? Second, there is the information heterogeneity (Moldoveanu et al., 2003), to what extent is particular information about the network structure shared (common) between firms. The heterogeneity aspect of the network horizon is an important determinant of the relative advantage of a firm to detect valuable network positions. The more common information about the network structure is, the larger the number of firms that will be aware of that particular network position. The probability for a given firm to compete for a position increases as the number of firms having the same information increases.

The network horizon of a firm is an important determinant of the opportunity set of firms to choose from when the focal firm is going to initiate a new interfirm relationship. The information a firm has of the entire network structure constrains the possible choices regarding establishing new ties, less information means less firms to choose from and therefore limits the possibilities of the focal firm to shift the network

[31] The network horizon is the codification (Boisot and Child, 1996) of information about the network structure. Codifying this information has two conflicting effects. One, codification of information about changes in the network is required for managerial action. If this information is not codified and processed it cannot communicated along a firm's hierarchy and this means that is less likely that decision-makers will incorporate the network horizon into their decision making process. Two, more codified information diffuses easier through a network compared with uncodified information and this means that firms will benefit shorter from this information because the time that the information was private to the time the information becomes public shortens as well. This means that the network horizon heterogeneity decreases over time. Thus, the network horizon is the codification of information about the network structure and is required for the decision making process but it also means that it will diffuse easier which shortens the time a firm can benefit from this information.

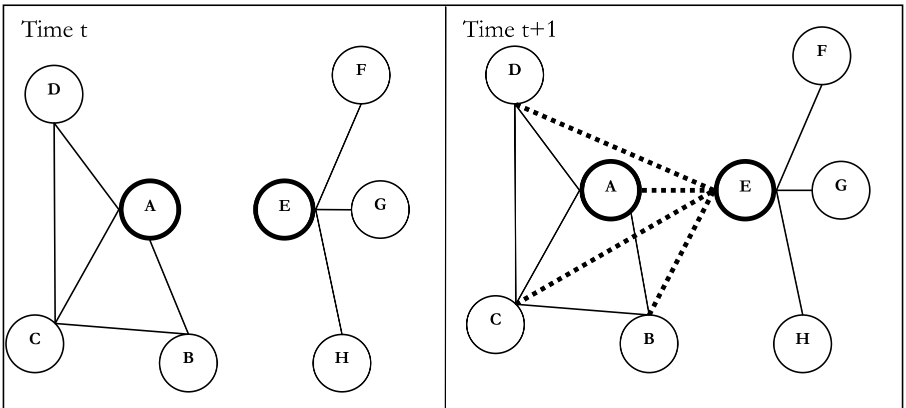
position. A firm with a more extended network horizon will be aware of more valuable network positions and will therefore have an advantage compared with a firm with a smaller network horizon in occupying this network position. A firm that is not part of the network horizon can still be considered as a potential partner by the focal firm. However, since information about the network position of the potential partner firm is lacking it is hard for the focal firm to estimate the effect of linking with that potential firm on the focal firms' bridging position. Firms outside the network horizon that are still known to the focal firm, so-called randomly known firms, can strengthen the bridging position of the focal firm. However, because these firms do not fall within the network horizon of the focal firm, it is less likely that these firms represent opportunities to strengthen the focal firms' bridging position because the technological or product distance is too large (Ahuja, 2000a) or other incompatibilities prevent either firm to benefit from establishing such an interfirm relationship. Hence, we hypothesize:

> *Hypothesis 1*: Firms with a more extended network horizon at time *t* will occupy a stronger bridging position at time *t+1*.

The second advantage of a more extensive network horizon is that a firm is able to span structural holes at a *faster rate*. The reason for this is that structural holes function as a source of information about the network structure. A firm occupying this position is more likely to detect opportunities to span new structural holes because it knows what benefits of a structural hole and is able to recognize similar opportunities in the network. Burt (2002: 334) noted in the context of individuals that "people [without structural holes] find it more difficult [compared with people who have structural holes] to see the structural holes in a network, and those whose own networks contain bridge relationships across structural holes more quickly learn new networks that contain structural holes". Network horizon is hypothesize to lead to a stronger bridging position (hypothesis 1) but this starts a virtuous cycle in which the firm is able to span new structural holes at a faster rate. These structural holes give information benefits in the form of awareness of new brokerage opportunities that allows the focal firm to strengthen its bridging position even more. As Burt (2002) notes, social capital accrues to firms which already possess social capital and this becomes a virtuous cycle. Therefore, we hypothesize:

Hypothesis 2: Firms with a more extended network horizon at time *t* will strengthen their bridging position at a faster rate at time *t+1*.

The intensity of competition for structural holes determines how many structural holes a single firm will span. Network horizon heterogeneity captures the degree of competitiveness in the network for network positions. The more common information is within the network about a given opportunity to span a structural hole, the more likely it is that more firms will pursue that given opportunity. Because a firm is inherently uncertain about the partnering actions its rivals will undertake, it will try to move first to occupy a bridging position. However, when multiple firms adhere to this logic then multiple firms will 'jump in' the structural hole to bridge it and effectively turn the hole into a closed position. Figure 4-1 illustrates this situation. Assume that firms A, B, C, and D have complete information of the network structure, while firms E, F, G, and H only aware are of each other.



	Effective size	Constraint		Effective size	Constraint
Firm A	1.667	0.840	Firm A	1.500	0.677
Firm B	1.000	0.889	Firm B	1.000	0.681
Firm C	1.667	0.840	Firm C	1.500	0.677
Firm D	1.000	0.889	Firm D	1.000	0.681
Firm E	3.000	0.333	Firm E	5.571	0.303
Firm F	1.000	1.000	Firm F	1.000	1.000
Firm G	1.000	1.000	Firm G	1.000	1.000
Firm H	1.000	1.000	Firm H	1.000	1.000

Figure 4-1 Illustration of the effect of network horizon heterogeneity

Firms A, B, C, and D realize the potential value that can be unlocked by bridging with firm E and firms F, G, and H have a limited network horizon that they are not aware of the existence of firms A, B, C, and D. Thus, this network is characterized by a high level of network horizon heterogeneity. Because firms A, B, C, and D are uncertain about the partnering actions each one is going to take, each firm individually decides to pursue the bridging position between firm E and firms A, B, C, and D. Furthermore, it is not realistic to expect that firms A, B, C, and D are going to coordinate who is going to bridge the position because being the *tertius gaudens* is a more favorable role (in terms of autonomy) than being exploited in a structural hole. The right panel illustrates the result. All four firms have established a tie with firm E and none of the four firms will enjoy the control benefits of the structural hole because that is foregone. Furthermore, because this network is highly redundant the information benefits are minimal as well. A reason why firm E may want to have more than one tie to the group of firms is to minimize its dependence on any one firm. Consequently, we hypothesize:

> *Hypothesis 3:* A high level of network horizon heterogeneity at time *t* will result in the weakening of the focal firms' bridging position at time *t+1*.

The combined effect of network horizon and network horizon heterogeneity leads to a moderating effect. A focal firm with an extended network horizon, in a network with a heterogeneous distribution of network horizons is able to sustain its network position longer since the limited network horizon of non-focal firms implies a lack of information regarding the potential location of structural holes and these firms are not able to compete for structural holes. This implies that the focal firm's position is more likely to be stronger.

> *Hypothesis 4:* Firms with a more extended network horizon at time *t* and in a network with high network horizon heterogeneity will have a stronger bridging position at time *t+1*.

The final hypothesis concerns the diminishing effect of network horizon. As the network horizon increases, the number of potential network positions that can be pursued increases as well. This requires the ability to distinguish 'very valuable' structural holes form 'valuable' structural holes. Pollock et al. (2004) observed that not every structural hole is as valuable, it takes training to be able to distinguish the very valuable from the valuable structural holes. Baum and Rowley (2004) found in the Canadian investment bank industry that managers have difficulty distinguishing unconstrained from constrained structural holes. Therefore, we hypothesize:

Hypothesis 5: There is a ∩[32] relationship between network horizon and the strength of the bridging position.

4.4 Methodology Study 1 – Network Experiments

We adopt a multi-method (Brewer & Hunter, 1989) approach for investigating the effect of network horizon and network horizon heterogeneity on the number of structural holes a firm spans. There are five reasons to adopt a multi-method approach (Mingers, 2001), the two most important reasons are increasing the internal validity and the generalizability of the study.

First, we use network experiments to test the hypotheses because it creates an environment in which it is possible to manipulate how participants use information in their decision-making to improve their network position. Second, we use computational modeling to explore the effect of network horizon and network horizon heterogeneity and the number of structural holes a firm spans in a large network. In this section of the chapter, we will not test the hypotheses but evaluate the effect size of network horizon and network horizon heterogeneity. We do not statistical test the hypotheses with the generated data from the computational model because given enough replications we will find significant results.

4.4.1 Participants and research design

We employed a random assigned within-subject design (Shadish et al., 2002). Three types of participants participated in the experiments. We had 210 managers from a large Dutch insurance firm and their insurance brokers participate as well as 126 students from different business administration graduate courses participate. Finally, we used a fixed student team (15 participants) that participated in multiple experiments. For the managers, insurance brokers, and the student team we used a scenario consisting of fifteen firms, for the graduate students we used a scenario of fourteen firms. The students participated individually in the experiments, the managers teamed up with an insurance broker. We will control for these differences by including dummy variables in

[32] The ∩ symbol denotes an inverted U-shaped relationship that suggests diminishing returns.

the analysis. We randomly assigned each participant to the condition of either a limited network horizon or a complete network horizon. We replicated the experiment fifty-three times in twenty-four sessions. In order to replicate experiments, we conducted multiple experiments in a single session. Table 4-1 summarizes the descriptions of the participants.

Participants	**Number of sessions**	**Number of experiments**	**Number of participants**	**Years of industry experience** (average / s. d.)	**Scenario used**
Managers & insurance brokers	7	12	210	15.49 /9.19	15 firms
Students	9	19	126	0.0 / 0.0	14 firms
Student team	8	22	15	0.0 / 0.0	15 firms
Total	**24**	**53**	**351**		

Table 4-1 Descriptives of the participants of the experiments

4.4.2 Network experiments

Each participant runs a firm in a business network that is situated in the insurance industry. A participant becomes the winner by simultaneously optimizing gross margin and net income. In order to improve its financial performance a participant has two key levers it can pull. First, a participant can change its network position by establishing a new tie or terminating an existing tie. Second, a participant can invest in new capabilities, specialize in existing capabilities, or dismantle current capabilities. These two levers are sometimes referred to as the 'make or buy' decision (Jacobides & Hitt, 2005). The experiments consists of two cycles, each cycle is five times repeated. The first cycle is the information-gathering period. A participant can analyze its current financial performance and devise alternative strategies (investing in a new relationship or investing in a capability) during this phase. The second cycle is called a decision point. A participant decides, during a decision point, to invest either in relationships or in capabilities. A decision point is succeeded by the next information-gathering period. This information-gathering period is used to assess the consequences of the decisions made during the previous decision point. These cycles last in total for thirty minutes per experiment. We refer for a more extensive description of the network experiments to Chapter 3.

4.4.3 Experimental procedure

The participants were seated behind a computer after arrival in the computer lab where the experiments were conducted. Before the experiments started, an extensive one-and-half hour explanation of the network experiment was given. During this explanation, the participants played one round of the network experiment to teach them where to find relevant information, how to make decisions, and how to assess the impact of their decisions. The data obtained from this practice round was discarded. Participants were free to ask the instructors questions about the interface of the network experiment. After the exercise round, control questions were distributed to verify whether the participants had a sufficient understanding of the network experiment to play it independently. Answers to these were checked and if necessary, some additional instruction was given to the participant before the experiments started. It was forbidden for participants to talk with each other and neither was there any help from the instructors during the second and third round, the rounds that were used for data collection. There was a debriefing session at the end of the experiments for educational purposes. The winner, the participant with the highest gross margin at the end of the experiments of a session was awarded with a gift coupon worth $25; the other participants received a fixed fee of $10.

4.4.4 Dependent variables

Number of structural holes the focal firm spans: we use two measures to count the number of structural holes of the focal firm. The first measure is effective size and the second measure is constraint. The definition for effective size is (Burt, 1992: 52):

Definition 20: effective size of firm i = $\sum_{j}\left(1-\sum_{q} p_{iq}m_{jq}\right), q \neq i, j.$

Sum *j* is the set of partner firms (alters). p_{iq} is the proportion of *i*'s network time and energy invested in the relationship with *q* and m_{jq} is the marginal strength of *j*'s relation with contact *q* (Burt, 1992: 51).

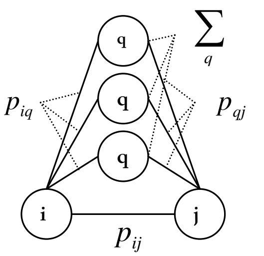
$$p_{iq} = \frac{(z_{iq} + z_{qi})}{\left[\sum_{j}(z_{ij} + z_{ji})\right]}, i \neq j \text{ and } m_{jq} = \frac{(z_{jq} + z_{qj})}{\max(z_{jk} + z_{kj})}, j \neq k$$

z_{jq} is the network variable measuring the strength of relation j to q (Burt, 1992: 51). Effective size measures the extent to which ties in the ego network are non-redundant and is therefore a measure of the information benefits of a structural hole.

When the degree of a firm (the number of ties it has) is equal to its effective size it means that every single tie gives access to new information. Effective size can never be greater than the degree of a firm. When the effective size is not equal to the degree of a firm than ego's network of the firm is to some extent redundant. Effective size is an unstandardized measure with values ranging from one to the network size minus one. We use this operationalization for the simulation as well.

For the robustness test, we calculate for each firm the strength of its bridging position by using Burt's (1992) network constraint measure. Constraint measures the extent to which a firm is dependent on its partner firms and is therefore a measure of the control benefits of a structural hole. When a firm it highly dependent on its network partners it means that it has little autonomy and therefore little control over the outcome of its activities. Constraint is a normalized measure with values ranging form zero to one where one means that a firm is very constrained and does not span any structural holes and zero means a firm is very unconstrained and spans many structural holes. This is contrary to the effective size measure, hence to clarify the interpretation of the network constraint variable we inverse this measure by taking 1- network constraint. Furthermore, we convert it to a percentage by multiplying it by 100. The definition for network constraint is (Burt, 1992: 60):

Definition 21: network constraint of firm i = $\left(p_{ij} + \sum_q p_{iq} p_{qj}\right)^2, i \neq q \neq j.$



i = focal firm, j = alter 1 firm i, q = alter n of firm i

p_{ij} = investment of firm i's time and energy in the relationship with firm j;

$p_{iq} p_{qj}$ = joint investment of time and energy of firm i and firm q in a relationship with firm j.

Figure 4-2 Illustration of network constraint

4.4.5 Independent variables

We use two different operationalizations for the network horizon independent variable. The first operationalization of network horizon is a dummy variable that states whether the focal firm has a limited or extended network horizon. This first operationalization is according to how we set up the experiment and we will use this operationalization for the robustness tests.

The second operationalization of network horizon is as follows. The concept of network horizon has a natural translation to the graph-theoretic concept of neighborhood (Bondy & Murty, 1976). To formally define network horizon, let the network be modeled as a graph G = (V, E); consisting of a vertex set V (the firms) and an edge set E (the ties between firms). Let d(u,v) be the geodesic distance between firms u and v, i.e. the smallest number of ties that need to be traveled to reach v from u. The k-neighborhood of firm u is then defined as:

Definition 22: k-neighborhood: $N_k(u) = \{v \in \mathrm{V} \mid \mathrm{d(u, v)} \leq \mathrm{k}\}$

In other words: the k-neighborhood of u consists of all firms v that can be reached from u in at most k steps, including u itself[33]. Firm u's network horizon is then defined as the percentage of firms of the total network that are in firm u's k-neighborhood, formally stated:

Definition 23: network horizon: $NH_k(u) = \frac{|N_k(u)|}{|V|} * 100\%$,

where $|N_k(u)|$ and $|V|$ denote the number of firms in u's k-neighborhood and V respectively and we will say that v is *within* u's network horizon when $v \in N_k(u)$. Note that this definition is general enough to allow for different definitions of distance to determine the neighborhood (see Ahuja, Ergun, Orlin, & Punnen, (2002) for an overview) as well as varying levels of k (the 'depth' of the neighborhood).

[33] Strictly speaking, *u* cannot be a neighbor of itself, but since we want to model formally a generalization of the ego network of *u*, we need to include *u* and hence adapt the definition of k-neighborhood accordingly.

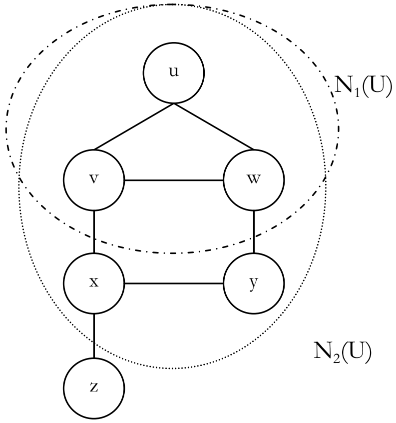


Figure 4-3 Illustration of the vertices in the k neighborhood for k=1 and k=2

A firm with a k-step network horizon has information about all the firms and ties that can be reached in maximum k steps. A limited network horizon is operationalized as a 2-step network horizon. A complete network horizon is operationalized as a network horizon that is equal to the longest geodesic distance plus one. A geodesic is the shortest path connecting two firms in a network. Suppose there is a fork network structure (see Figure 4-4) with four firms (A, B, C, and D). A is connected to B, B is connected to C and to D and C and D are connected. When the network horizon of A would be equal to the longest geodesic distance from A to D, which is two, then A would be unaware of the tie between C and D.

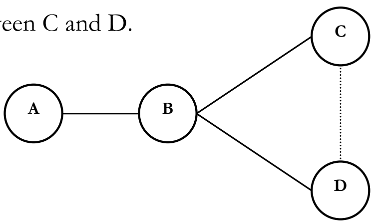


Figure 4-4 Illustration of k-step network horizon

Therefore, to have a network horizon that captures the whole network structure, the network horizon should be equal to the longest geodesic distance plus one. The longest geodesic distance is a path of eight in the network experiment. Thus, the complete network horizon in the experimental setting equals nine steps. The 2-step operationalization is consistent with Friedkin's (1983) finding that people have difficulty observing the network more than two steps away and is consistent with the local tie approach Baum *et al.* (2005) introduces. The full network horizon is consistent with the (implicit) assumption underlying most network literature that firms have complete knowledge of the network.

The second operationalization of network horizon is a continuous variable that counts how many firms the focal firm can 'see'. For firms with a limited network horizon we count the number of firms that can be reached within two steps, for firms that have an extended (or full) network horizon the number of firms the focal firm sees is equal to the network size (depending on the scenario 14 or 15 firms). This variable is updated after each decision point.

The second independent variable is the rate at which the bridging position is strengthened. We calculate this by multiplying network horizon and time and use this variable to test hypothesis 2 (Singer & Willett, 2003).

The independent variable network horizon was randomly assigned to the participants using the configuration tool belonging to the network experiment environment – assigning individual firms a network horizon is an implicit configuration of the network horizon heterogeneity. The network horizon heterogeneity was determined using the ratio of firms with a limited network horizon and firms with a complete network horizon. Figure 4-5 and Figure 4-6 illustrate the effect of having a limited or a full network horizon in the network experiment environment. Different ratios of individual network horizons translate into different levels of network horizon heterogeneity. There are multiple ways to conceptualize this heterogeneity, each with different underlying theoretical rationales (see Klein & Harrison (2007) for more detail on the different ways). The underlying attribute that is heterogeneous (network horizon) represents a socially valued asset or resource of the firms, the appropriate conceptualization is of the disparity-type, which can be measured by the inequality or relative concentration measures such as the Gini-coefficient or the coefficient of variation (Klein & Harrison, 2007). We opt for the Gini-coefficient (Weisstein, 2006), which results in the following definition of network horizon heterogeneity (NHH) for a given network G (V,E):

Definition 24[34]: $NHH(G) = \dfrac{\sum_{u \in V} \sum_{v \in V} \left| NH_k(u) - NH_k(v) \right|}{2|V|^2 \mu}$

where μ represent the average network horizon of all actors in G and k represents the number of steps a firm can see in its network. A network horizon heterogeneity value of zero indicates that there is perfect equality of the network

[34] The Gini coefficient is calculated as the mean difference between every possible pair of firms, divided by the mean.

horizons among the different firms. A value of one indicates that there is maximum inequality: one firm has information about the whole network structure and the other firms do not have any information. We use this operationalization for the simulation as well. This is the third independent variable.

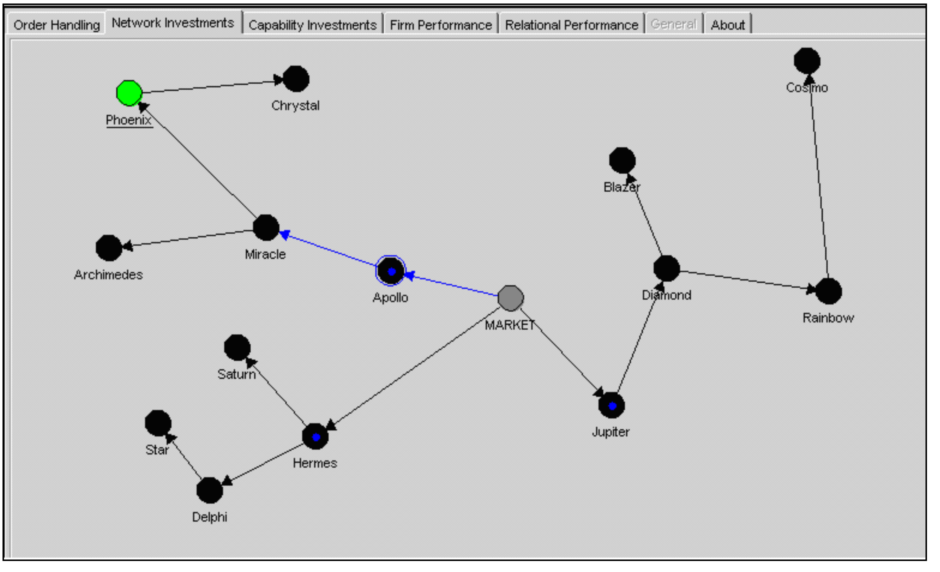


Figure 4-5 Screenshot network experiment with full network horizon (focal firm Phoenix)

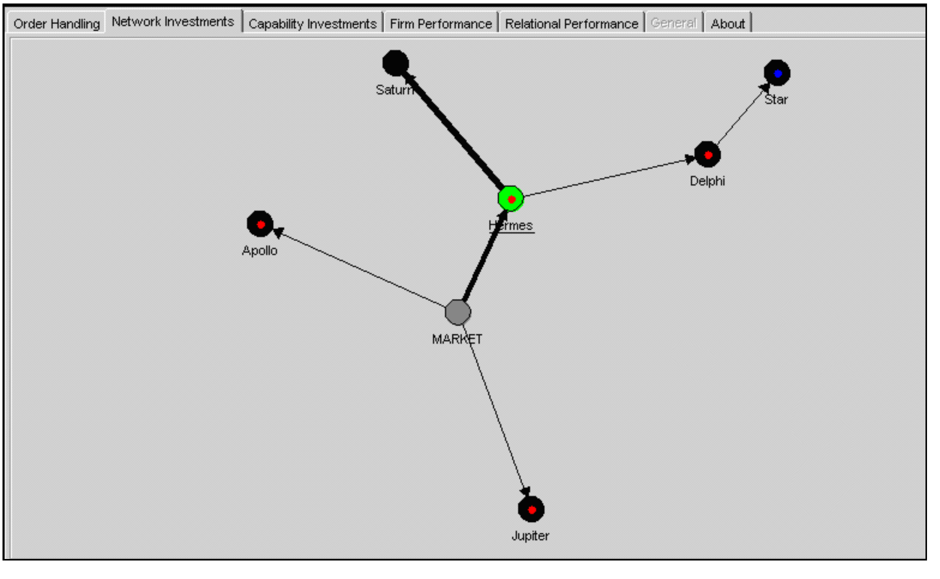


Figure 4-6 Screenshot network experiment with limited network horizon (focal firm Hermes)

The fourth independent variable is the network horizon heterogeneity multiplied by time (Singer & Willett, 2003), this variable is used to measure the rate of change of the strength of a bridging position due to the network horizon heterogeneity. The fifth and final independent variable is network horizon squared; we use this variable to measure the diminishing returns of network horizon.

4.4.6 Control variables

We add the following control variables to rule out alternative explanations for the strengthening of a firm's bridging position:

Density. A denser network indicates the existence of dense cliques. Brokering between such cliques has a positive effect on the strength of a bridging position and thus networks with a higher level of density will have firms with stronger bridging positions. Density is calculated as: $\frac{\sum x_{ij}}{n(n-1)}, i \neq j$ where x_{ij} represents the value of a relationship between *i* and *j* (assuming that x_{ij} only takes values of 0 or 1) and n is the number of nodes in the network.

Effective size at t-1 / network constraint at t-1. A firm that spans many structural holes at t-1 will span many structural holes at t because the structural holes gives information advantages to discover new structural holes.

Outdegree. A firm with a greater outdegree will span more structural holes compared with a firm with a lower outdegree. Outdegree centrality is calculated as: $\sum_i x_{ij}$ or the sum of relationships firm *i* maintains.

Betweenness centrality. A firm with a greater betweenness centrality is more often on the shortest path between any two random chosen firms and will therefore span more structural holes. Betweenness centrality is calculated as: $\sum_i \sum_j \frac{g_{ikj}}{g_{ij}}, i \neq j \neq k$ g_{ij} is the number of geodesic paths from *i* to *j*, g_{ikj} is the number of geodesic paths that pass along *k* and a geodesic path is the shortest path connecting two nodes in a network (Wasserman & Faust, 1994).

Number of capabilities owned. The more capabilities a firm owns the less dependent this firm becomes on other firms and will therefore span fewer structural holes.

Attractiveness partner firms. Partner firms that posses many capabilities are more attractive to partner with compared with partner firms that fewer capabilities. Thus, if the focal firm has access to attractive partners then it is likely that firms will partner with a bridging firm that has the most attractive partners. This variable is calculated by summing the total number of capabilities possessed by the partner firms and divided by the number of partner firms.

Furthermore, we add dummy variables for each firm, each type of strategy, a firm's initial network position and the size of the network.

4.5 Analysis and Results – Network Experiments

We use a multi-level model with random coefficients and random slopes to estimate the effect of network horizon and network horizon heterogeneity on the number of structural holes a firm spans. We use a multi-level model with random effects and random slopes to determine: a) whether there is a difference in the intercept of the number of structural holes a firm spans because of a firm's network horizon and b) whether there is a difference in the rate of spanning new structural holes because of a firm's network horizon. Furthermore, the observations are nested in multiple levels: the firm observations are nested in the experiment observations; this requires a multi-level model to take into account this dependence. We control for the following differences between the firms that remain constant throughout the experiment such as different strategies (product leadership, customer intimacy and operational excellence), different initial network position, different cost structures for the different capabilities, whether students or managers were the participants of the experiments and if the scenario consists of fourteen or fifteen firms.

We estimate five models with as dependent variable firm effective size. The first mode is the unconditional growth model. This model depicts the general trend we observe in the 53 experiments. This model is used as a baseline to calculate to what extent the next models improve upon this model. There are no predictor variables in this model except for time. Before continuing the analysis, we first test whether the experimental treatment (network horizon is limited vs. network horizon is full) leads to different averages of the effective size of a firm. Running a one-way ANOVA confirms that at each time observation the means are significantly different ($p = 0.000$). Table 4-2 summarizes the means, standard deviation, minimum, and maximum for each variable (excluding the dummy variables).

	Variables	Mean	S.D.	Min	Max	1	2	3	4	5	6	7	8
1.	Effective size	2.8343	1.5705	0	9.3182	1							
2.	Effective size at t-1	2.6813	1.492	0	9.3182	0.824	1						
3.	Network constraint	0.4967	0.2401	0.1	1	-0.7991	-0.6437	1					
4.	Network constraint at t-1	0.5126	0.2466	0	1	-0.6481	-0.7615	0.701	1				
5.	Time	2.5642	1.6623	0	5	0.3795	0.3704	-0.358	-0.3365	1			
6.	Density	0.1227	0.0435	0.0578	0.2311	0.4583	0.4301	-0.4582	-0.4044	0.8119	1		
7.	Outdegree	1.771	1.8564	0	11	0.8345	0.7522	-0.595	-0.5547	0.3062	0.3637	1	
8.	Betweenness centrality	0.0609	0.0997	0	0.8465	0.5088	0.4172	-0.3912	-0.329	0.1954	0.2881	0.4476	1
9.	Number of capabilities owned	2.036	0.9276	0	8	0.1582	0.134	-0.1333	-0.1288	0.2942	0.2673	0.1944	0.0563
10.	Attractiveness partner firms	0.6198	0.338	0	1	0.1096	0.0577	-0.0695	-0.0174	0.0215	0.0358	0.0642	0.0439
11.	Network horizon	12.134	4.4887	0	16	0.3908	0.3602	-0.4438	-0.3523	0.277	0.4143	0.2559	0.1847
12.	Rate of change network horizon	33.1813	25.1254	0	80	0.4939	0.492	-0.4916	-0.4475	0.9177	0.8253	0.3718	0.2455
13.	Network horizon heterogeneity (nhh)	0.3968	0.347	0	0.5208	-0.1216	-0.1437	0.0881	0.1267	-0.2958	-0.458	-0.0945	-0.0653
14.	Rate of change nhh	2.9195	3.0711	0	22.0861	0.1697	0.0571	-0.1636	-0.0341	0.4609	0.1295	0.1437	0.0881
15.	Network horizon^2	167.3777	87.8534	0	256	0.3646	0.3451	-0.3959	-0.3335	0.2318	0.3773	0.2332	0.1663
	Variables (continued)	**9**	**10**	**11**	**12**	**13**	**14**	**15**					
9.	Number of capabilities owned	1											
10.	Attractiveness partner firms	-0.1457	1										
11.	Network horizon	0.0777	0.0579	1									
12.	Rate of change network horizon	0.256	0.039	0.5359	1								
13.	Network horizon heterogeneity	-0.1234	-0.0024	0.1047	-0.2616	1							
14.	Rate of change nhh	0.1311	0.0186	0.1501	0.4077	0.4534	1						
15.	Network horizon^2	0.0605	0.062	0.9871	0.5058	0.1065	0.1066	1					

Correlations > |.11| are significant at $p < 0.001$, dummy variables excluded from correlation table; number of observations is 3599. NHH = network horizon heterogeneity

Table 4-2 Descriptive statistics and correlations

The second model is a baseline model, this model explains the number of structural holes a firm spans based on the control variables. The third model adds the network horizon main effect to test hypothesis 1 (network horizon leads to more structural holes) and hypothesis 2 (network horizon leads to a faster rate of spanning structural holes). In the fourth model, we test hypothesis 3, we add the effect of network horizon heterogeneity on the number of structural holes a firm spans and hypothesis 4 that a greater inequality of network horizon among the firms leads to a faster rate of spanning new structural holes. Finally, the fifth model adds the diminishing effects of network horizon to test hypothesis 5. The estimates of the coefficients are robust across the three models and all three models are significant (p = 0.0000). However, according to the AIC information criterion is model 5 the best fitting model and according to the BIC information criterion is model 3 the best fitting model. We interpret the results based on model 5 because the direction and significance of model 3 and model 5 are compatible. The results of these models are presented in Table 4-3.

The effect of network horizon is positive and significant, confirming hypothesis 1 that states that firms with a more extended network horizon are more aware of brokerage opportunities and hence will span more structural holes. This finding is illustrated in Figure 4-7.

Dependent variable is effective size	Hypothesis and expected sign	Model 1 - Unconditional growth	Model 2 - Baseline model	Model 3 - Main effect	Model 4 - Network horizon heterogeneity effect	Model 5 - Diminishing returns to network horizon
Time		0.327***	-0.009	-0.193***	-0.210***	-0.225***
		0.014	-0.017	-0.035	-0.038	-0.038
Effective size at t-1			0.113***	0.100***	0.101***	0.109***
			0.014	0.013	0.013	0.013
Density			5.743***	3.392***	2.986***	2.615**
			0.736	0.702	0.794	0.803
Outdegree			0.516***	0.504***	0.502***	0.502***
			0.013	0.013	0.013	0.013
Betweenness centrality			2.237***	2.064***	2.047***	2.043***
			0.142	0.136	0.136	0.136
Number of capabilities owned			-0.127***	-0.105***	-0.110***	-0.109***
			-0.021	-0.02	-0.02	-0.02
Attractiveness partner firms			0.017	0.029	0.018	0.021
			0.052	0.05	0.05	0.05
Network horizon	**H1: +**			0.034***	0.037***	0.099***
				0.006	0.007	0.02
Rate of change network horizon	**H2: +**			0.015***	0.015***	0.016***
				0.002	0.003	0.003
Network horizon heterogeneity	**H3: -**				-0.064**	-0.063**
					-0.021	-0.021
Rate of change network horizon	**H4: +**				0.023**	0.018*

Dependent variable is effective size	Hypothesis and expected sign	Model 1 - Unconditional growth	Model 2 - Baseline model	Model 3 - Main effect	Model 4 - Network horizon heterogeneity effect	Model 5 - Diminishing returns to network horizon
heterogeneity					0.009	0.009
Network horizon^2	**H5: -**					-0.003**
						-0.001
Control variables included		No	Yes	Yes	Yes	Yes
Initial status intercept		2.040***	1.167***	1.007***	1.113***	0.947***
		0.072	0.196	0.195	0.198	0.203
Variance Components						
Level 1	Within firm	0.4335237	0.2682133	0.2540137	0.2540226	0.2564837
Level 2	In initial status	1.277857	0.2765944	0.2670362	0.2623271	0.2446364
	In rate of change	0.1015733	0.0357258	0.0318909	0.0317817	0.0309005
	Covariance	-0.0894696	-0.0576923	-0.0532466	-0.0526199	-0.0497562
AIC		10197.274	7363.825	7126.955	7121.177	7113.184
BIC		10240.590	7574.231	7349.738	7356.336	7354.532
N		3599	3599	3599	3599	3599
Δ Log-Likelihood				240.87***	9.78**	9.99***
Observation type	Number of observations (per group)	Minimum	Average	Maximum		
Number of experiments	53	42	67.9	75		
Number of firms	759	3	4.7	5		

Control variables include firm strategy, network position, manager or student, scenario (14 or 15 firms) and firm characteristics. * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 4-3 Multi-level random intercept random coefficient model of the relationship network horizon – firm effective size

White indicates that a firm has a full network horizon; black indicates that a firm has a limited network horizon. Size of the sphere indicates the effective size; the size of the sphere is proportional to the number of structural holes it spans (measured as effective size). Hypothesis 2 is confirmed as well; the direction of coefficient is as expected and is significant. This finding suggests that firms that have a more extended network horizon not only span more structural holes but also at a faster rate compared with firms that have a limited network horizon.

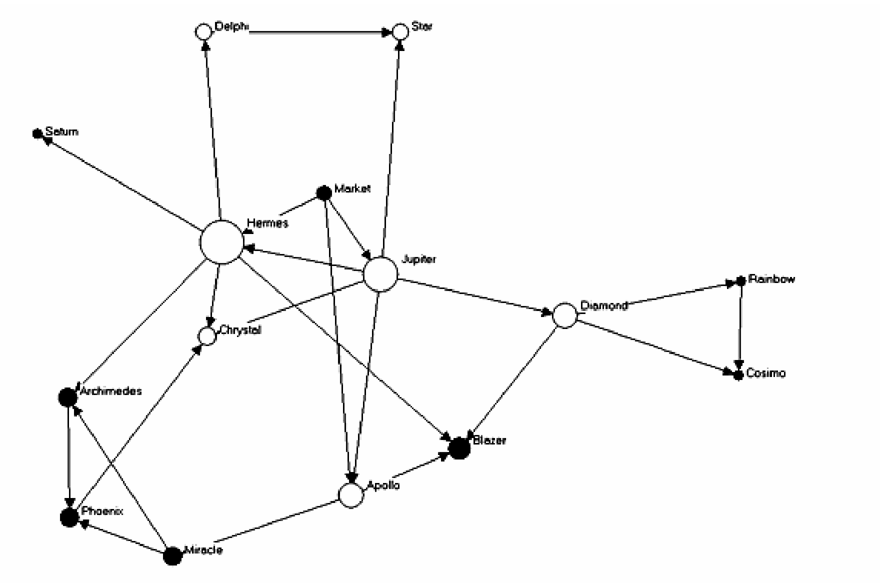


Figure 4-7 Network structure at the end of an experiment

The coefficient for the third hypothesis is negative and significant as we predicted in hypothesis 3. The focal firm is worse off because the competition for structural holes intensifies when there is a greater heterogeneity between the firms about what they know of the network structure. Higher network horizon heterogeneity indicates that a small group of firms spot valuable brokerage opportunities that lead to a temporal strengthening of the focal firm's bridging position but the partnering decisions of the competing firms are likely to adversely impact the bridging position of the focal firm. The sustainability of a bridging position will be further investigated in Chapter 5. The coefficient of the fourth hypothesis is positive and significant, in line with hypothesis 4. This means that as the competition for valuable brokerage positions intensifies, the firms that have a comparative advantage will be able to span at faster rate new structural holes. This finding is consistent with the finding in hypothesis 2. Finally, the fifth hypothesis is significant; the direction of the coefficient is coincides with our expectations. This finding suggests that there might be a point where too much information about the network structure leads to sub-optimal decision-making. This suggests that bounded rationality plays a role during the partnering decision-making process. Participants have increasingly difficulty to shift their network position and to assess accurately the impact of their partnering decision on the strength of their bridging position as more information about the network structure becomes available. The participants (in the experiments) start to have difficulty with analyzing all the information about the network structure and do not recognize the opportunity to span new structural holes while these brokerage opportunities do exist. An alternative explanation could be that there is a limited information processing capacity of the participants due to the short time given to them to make their decisions.

4.5.1 Robustness tests

In order to increase the convergent validity of the previous findings, we re-estimate the previous model using two alternative operationalizations. First, we estimate four new models with as dependent variable network constraint; see Table 4-4 for the new models. The coefficients are significant and the signs of the coefficients are according to our predictions and thus confirming our hypotheses. Second, we estimate the full model using effective size as the dependent variable for the sub population of the managers and the sub population of the student team (see Table 4-5). The robustness tests confirm the previous findings, leading to the overall conclusion that network horizon and network horizon heterogeneity are significant predictors of the number of structural holes a firm spans.

Network horizon is a robust predictor of the number of structural holes a firm spans. However, what is the magnitude of this effect? Table 4-6 present the effect sizes of the network horizon of a firm. The average effective size in the experiments was 2.8340 structural holes. The focal firm is able to expand its effective size with 1.2594 firms, which is an increase of 44.44%. Intense competition for structural holes is expected to decrease the effective size of the focal firm by 8.49% or a reduction in its effective size of -0.2405.

The dependent variable is network constraint (reverse coded)	Hypothesis and expected sign	Model 1 - Unconditional growth	Model 2 - Baseline model	Model 3 - Main effect	Model 4 - Network horizon heterogeneity effect	Model 5 - Diminishing returns to network horizon
Time		5.246***	-0.353	-3.766***	-4.847***	-7.008***
		0.195	0.33	0.615	0.652	0.635
Constraint at t-1			0.120***	0.118***	0.122***	0.184***
			0.013	0.012	0.012	0.012
Density			180.835***	105.350***	130.695***	97.296***
			14.035	13.038	14.829	14.63
Outdegree			1.847***	1.449***	1.395***	1.484***
			0.239	0.212	0.212	0.196
Betweenness centrality			21.412***	16.257***	15.668***	14.977***
			2.62	2.374	2.36	2.265
Number of capabilities owned			-1.725***	-0.945**	-1.040**	-0.949**
			0.383	0.337	0.335	0.309
Attractiveness partner firms			-0.141	0.143	-0.073	0.123
			1.035	0.947	0.945	0.894
Network horizon	**H1: +**			1.450***	1.238***	5.924***
				0.142	0.157	0.348
Rate of change network horizon	**H2: +**			0.267***	0.284***	0.448***
				0.043	0.043	0.043
Network horizon heterogeneity	**H3: -**				-0.447	-0.895
					0.484	0.466
Rate of change network horizon	**H4: +**				0.639***	0.442**

The dependent variable is network constraint (reverse coded)	**Hypothesis and expected sign**	**Model 1 - Unconditional growth**	**Model 2 - Baseline model**	**Model 3 - Main effect**	**Model 4 - Network horizon heterogeneity effect**	**Model 5 - Diminishing returns to network horizon**
heterogeneity						0
Network horizon^2	**H5: -**					-0.265***
						0.018
Control variables included		No	Yes	Yes	Yes	Yes
Initial status intercept		36.975***	29.210***	19.409***	19.290***	8.689**
		1.273	3.689	3.5	3.547	3.286
Variance Components						
Level 1	Within firm	1.885***	0.790**	0.516	0.337	0.458
Level 2	In initial status	1.443***	1.467***	1.385***	1.377***	1.219***
	In rate of change	3.114***	2.929***	2.929***	2.924***	2.767***
	Covariance	-0.976***	-1.328***	-1.620***	-1.633***	-1.822***
AIC		37073.234	28770.192	28262.284	28244.08	28057.142
BIC		37117.89	28986.79	28491.25	28485.43	28304.68
N		3599	3599	3599	3599	3599
Δ Log-Likelihood				511.91***	22.20***	188.94***
Observation type	Number of observations (per group)		Minimum	Average	Maximum	
Number of experiments	53		42	67.9	75	
Number of firms	759		3	4.7	5	

Control variables include firm strategy, network position, manager or student, scenario (14 or 15 firms) and firm characteristics. * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 4-4 Multi-level random intercept random coefficient model for the relationship network horizon – network constraint

Dependent variable is effective size	Hypothesis and expected sign	Model 3 - Main effect (managers as participants)	Model 3 - Main effect (student team as participants)	Model 5 - Main effect (student team as participants)
Time		-0.353**	-0.092*	-0.123**
		0.108	0.04	0.045
Effective size t-1		0.068*	0.116***	0.126***
		0.029	0.02	0.02
Outdegree		0.455***	0.549***	0.550***
		0.028	0.018	0.018
Betweenness centrality		1.700***	2.292***	2.221***
		0.279	0.21	0.211
Number of capabilities owned		-0.083	-0.085**	-0.098***
		0.045	0.028	0.028
Attractiveness partner firms		0.278*	-0.062	-0.088
		0.132	0.062	0.061
Network horizon	**H1: +**	0.031*	0.033***	0.149***
		0.016	0.007	0.023
Rate of change network horizon	**H2: +**	0.025***	0.013***	0.012***
		0.007	0.003	0.003
Network horizon heterogeneity	**H3: -**			-0.113***
				0.032
Rate of change network horizon heterogeneity	**H4: +**			-0.005***
				0.001
Network horizon^2	**H5: -**			0.024*
				0.011
Constant		-0.677	1.838***	1.672***
		0.808	0.305	0.315
AIC		1783.33	2659.28	2630.13
BIC		1947.899	2841.803	2828.758
Number of observations		814	1585	1585

* p<0.05, ** p<0.01, *** p<0.001

Table 4-5 Re-estimated models for the student team and managers as participants

Coefficient	**Coefficient (full model)**	**Standard deviation**	**Effect size**	**Impact on effective size**
Network horizon firm i	0.099	4.4890	0.4444	1.2594
Network horizon x network horizon heterogeneity	-0.063	1.3470	-0.0849	-0.2405

Table 4-6 Effect size of network horizon on the effective size of a firm

The previous sections showed that network horizon is a robust predictor of the number of structural holes a firm spans. Figure 4-8 visualizes models 3 (panel 1) and 5 (panel 2) of Table 4-3. Both models are consistent in their prediction that firms with limited network horizon (defined as average horizon minus one standard deviation which is roughly 5 firms) will see their effective size decrease over time. What is striking about panel 1 of Figure 4-8 is that the slope of the line for full network horizon is very gentle. This suggests that network horizon is a required but insufficient condition for a firm to be able to span structural holes. Even though the information about brokerage opportunities is available, participants in the experiments were, on average, not able to increase their effective size. The implication of this finding is that participants do not understand the benefits of a structural hole *ex ante* of the experiment. This finding is consistent with Burt and Ronchi's (2007) finding that teaching executives about the structure of social capital enhances their performance because of their better understanding of how social capital functions.

Panel 2 illustrates the effect of incorporating network horizon heterogeneity and shows that even though individuals may not be able to increase their effective size, they can increase their effective size because of the inequality between firms in their network horizon.

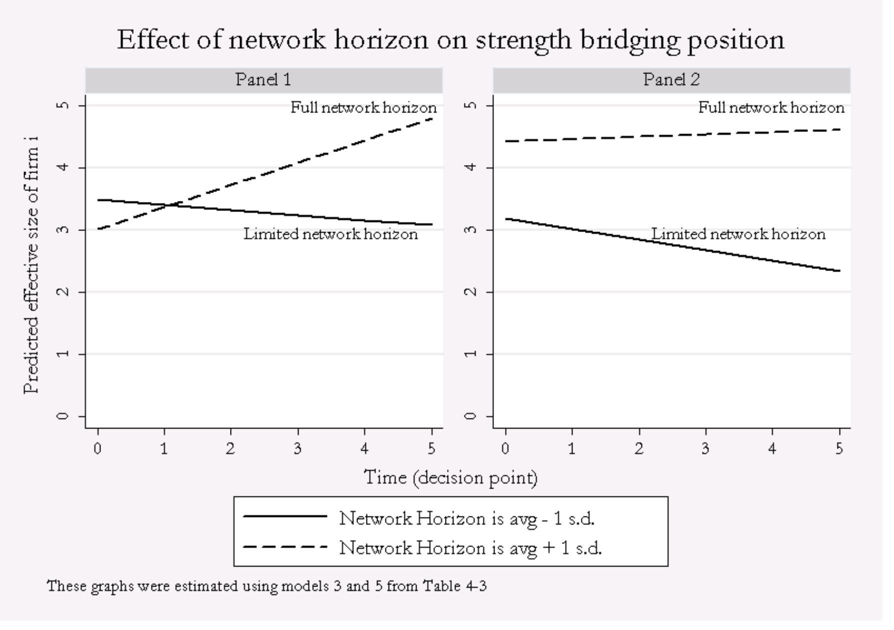


Figure 4-8 Illustration of model 3 and model 5

Depending on the participant group there is a different explanation why this particular group did not span more structural holes even though the information to do so was available. There are two reasons why students are able to span more structural holes than the managers did. First, students from the student team repeatedly participated with the experiments and hence gained a better understanding of how to make a firm profitable. Because the experiments were designed in such a way that it is beneficial to span structural holes, the students discovered that to be more profitable it is advantageous to span structural holes. Although they did not know the concept of a structural hole, they did understand that occupying a brokering position helped them in winning an experiment.

Students have less knowledge about how the insurance industry functions and are therefore freer to take advantage of the information given to them. Students are not constrained by 'industry rules' while managers who have worked their entire career in this specific industry are more inclined to adhere to the way business is done as they know it. Figure 4-9 illustrates how students and managers differ in their capability of spanning structural holes. Students from the student team learn how to recognize brokerage opportunities and span significant more holes at a faster rate compared with the managers as participants. Furthermore, they seem to learn how to mitigate the effect of a limited network horizon and have a less steep decline of their effective size. However, an alternative explanation should also be noted: members of the student team become more proficient in using and understanding the network experiment. This experience increases their ability to strengthen their firms' bridging positions.

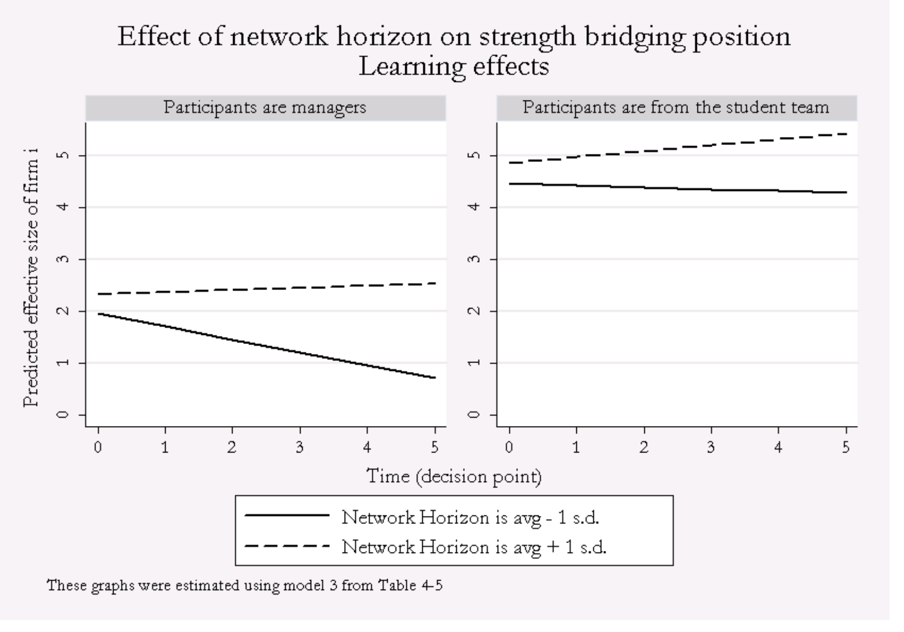


Figure 4-9 Illustration of effect network horizon for managers and students

4.6 Methodology Study 2 – Computational Modeling

The second study continues with the conclusion of the first study, namely that network horizon is a required but insufficient condition for a firm to shift its network position. In the second study, we use a computational modeling approach that overcomes two drawbacks of the first study. First, using a computational modeling approach allows us to model network behavior in which all the firms are acting in a network position optimizing way. In the first study, it was beneficial for participants to span structural holes however; it required them to grasp the concept of structural holes. With the computational modeling approach, we model the behavior of firms in such a way that firms will try to span as many structural holes as possible. Second, a computational modeling approach allows us to use larger networks with greater network horizon heterogeneity. Therefore, using a computational approach to model explicitly the network horizon of individual firms we can investigate under different circumstances the effect of network horizon and the number of structural holes a firm spans. Furthermore, simulation studies can be used to create new and novel theories through systematic experimentation (Davis, Bingham, & Eisenhardt, 2007). Especially when data are hard to obtain (Gibbons, 2004) or non-linear, longitudinal, and multi-level processes are studied (Davis et al., 2007). We discuss the computational model and the partnering algorithm in detail in Chapter 5 (on page 132) because Chapter 5 is solely based on the simulation. The data that are used for the analysis in this chapter are the same as in Chapter 5.

4.7 Analysis and Results – Computational Model

We ran fifteen different experimental settings with the simulation. For sake of simplicity, we use two groups of firms each with a different network horizon. In the first four sessions, we keep the network horizon heterogeneity constant at 0.00 and increase the network horizon from 5 firms (5% of entire network structure is known to a firm) in session 1 to 50 firms (50% of entire network structure is known to a firm) in session 4.

	Experimental condition NHHs,t=0	**Experimental condition average network horizon (at t=0)**	**Assigned random term group 1 (N is number of firms, α = random term)**	**Assigned random term group 2**
Session 1	.000	5 firms		N = 100; α = 5 firms
Session 2	.000	10 firms		N = 100; α = 10 firms
Session 3	.000	25 firms		N = 100; α = 25 firms
Session 4	.000	50 firms		N = 100; α = 50 firms
Session 5	.250	5.47 firms	N = 93; α = 4 firms	N = 7; α = 25 firms
Session 6	.250	10.3 firms	N = 78; α = 7 firms	N = 22; α = 22 firms
Session 7	.248	25.28 firms	N = 86; α = 18 firms	N = 14; α = 70 firms
Session 8	.253	53.54 firms	N = 27; α = 17 firms	N = 63; α = 75 firms
Session 9	.521	4.99 firms	N = 87; α = 2 firms	N = 13; α = 25 firms
Session 10	.500	12.36 firms	N = 84; α = 5 firms	N = 16; α = 51 firms
Session 11	.499	25.28 firms	N = 63; α = 8 firms	N = 37; α = 72 firms
Session 12	.496	42.3 firms	N = 53; α = 9 firms	N = 47; α = 99 firms
Session 13	.751	6.39 firms	N = 89; α = 1 firm	N = 11; α = 50 firms
Session 14	.750	12.67 firms	N = 89; α = 2 firms	N = 11; α = 99 firms
Session 15	.745	22.56 firms	N = 78; α = 1 firm	N = 22; α = 99 firms
Session 16	It is not possible to have a network with 100 firms, average network horizon of 50 firms and network horizon heterogeneity of .75. This can only be achieved by increasing the network size.			

Table 4-7 Configuration of computational model

In the next four sessions (session 5 to session 8), we keep the network horizon heterogeneity constant at .25 and run a session with average network horizon of 5%, 10%, 25% and 50% (to replicate the first four sessions). Session 9 to session 12 have a network horizon heterogeneity of .50 and session 13 to 15 have a network horizon heterogeneity of .75. Due to rounding errors, some sessions do not exactly match the initial values of the first four sessions. Table 4-7 summarizes the experimental setup of the simulation. Figure 4-10 gives a first illustration of the relationship between network horizon and the average strength of a bridging position. This figure controls for the density of the network. As expected, as the density of the network increases so does the average strength of a bridging position. This figure illustrates clearly that as a firm expands its network horizon, it strengthens its bridging position. This relationship is even more pronounced as the density of the network increases.

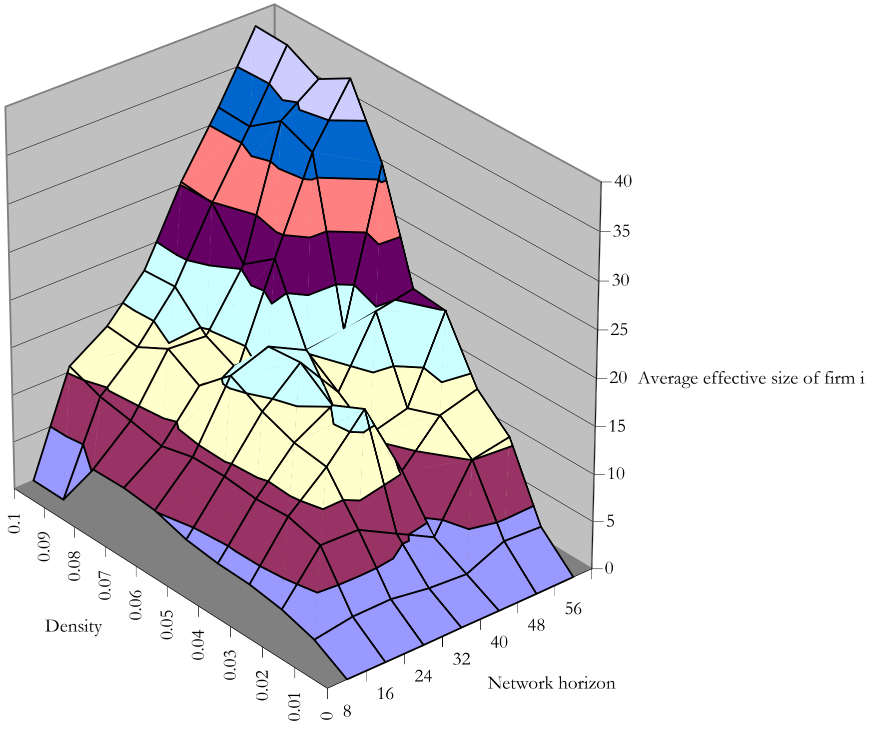


Figure 4-10 Average effective size, density and network horizon

The next figure, Figure 4-11, illustrates the relationship between average strength of a bridging position, network horizon and network horizon heterogeneity. The average strength of a bridging position increases as the network horizon expands from zero firms to 56 firms assuming a low level of network horizon heterogeneity. The average effect of network horizon diminishes as the network horizon heterogeneity increases but this is because this figure represents averages for all the firms in the network. This suggests that there are diminishing returns to network horizon. For a given network, there is a certain level of completeness of the network horizon within the network that once it has been reached, a firm will not benefit from any additional information that leads to further improvement of the network position. This finding of diminishing returns is consistent with hypothesis 5 of the previous study, which suggested the existence of a ∩-shaped relationship between network horizon and the number of structural holes a firm spans. A greater heterogeneity indicates that on average most firms have a limited network horizon while a few firms have a very extensive network horizon. This means that, on average, firms have a weaker bridging position.

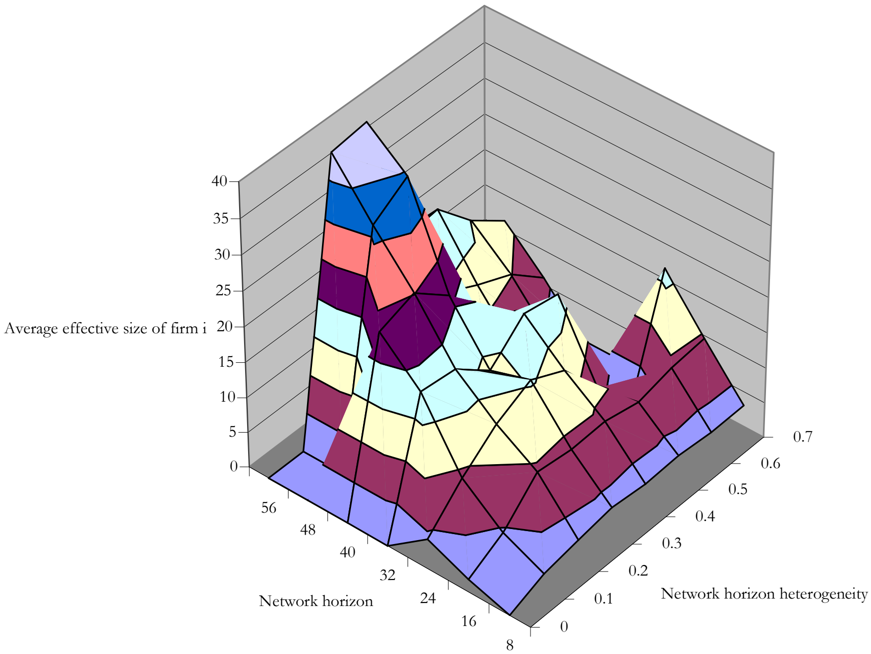


Figure 4-11 Average effective size, network horizon and network horizon heterogeneity

Increased levels of network horizon heterogeneity result in more dynamic bridging positions as is illustrated by Figure 4-12. Especially firms with a high network horizon in a network characterized by a high level of network horizon heterogeneity experience increased levels of competitions since the variance of the strength of their

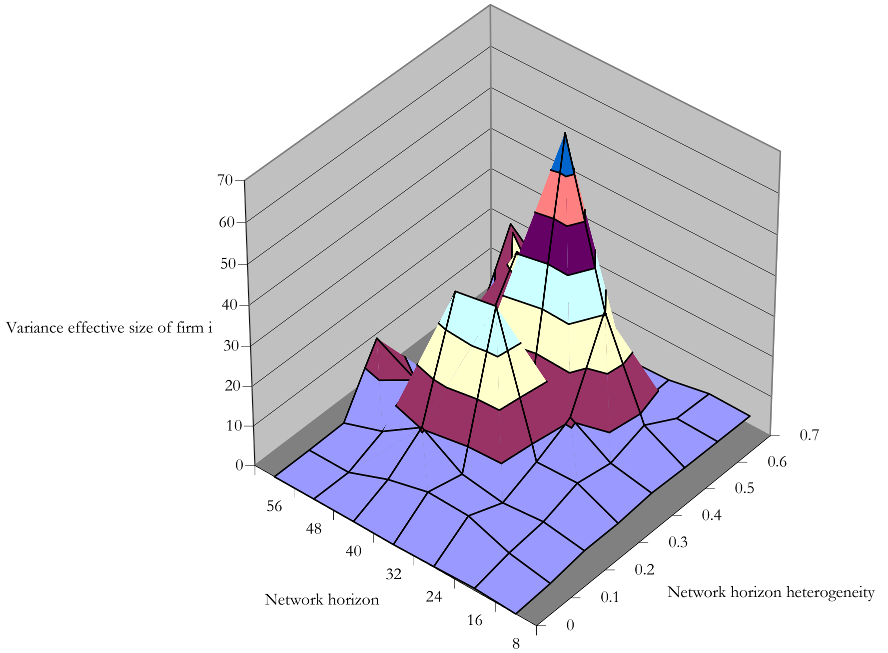


Figure 4-12 Variance effective size, network horizon and network horizon heterogeneity

4.8 Conclusion

This study demonstrates, using both network experiments and computational modeling, that the network horizon of a firm is one of the factors that explain why certain firms span more structural holes in their network than other firms do. In an extensive review on the literature about structural holes done by Burt (2000) he concluded that "structural holes are the source of value added, but network closure can be essential to realizing the value buried in the holes". The most rational action from the perspective of an individual firm is to maximize the number of structural holes in its network. This study indicates that in order to maximize the number of structural holes it is important to have an extensive network horizon but this in itself is an insufficient requirement. Firms, in essence the people running firms, have to recognize the value a brokerage opportunity represents. Only when decision-makers understand the value of a brokerage network position and have sufficient information about the network structure then they will be able to span more structural holes and hence improve their firm's network position. Only when these two conditions are satisfied will a firm span more structural holes if it has an extensive network horizon.

The second finding of this study is that the network horizon heterogeneity is a robust predictor for the difference in the number of structural holes a firm spans. Networks that are more heterogeneous lead to greater differences between firms in the strength of their bridging positions.

This research raises a new challenge for management: given the fact that resources are scarce and a more expanded network horizon can be beneficial, which area of a network structure should be monitored? As most networks are invisible, it is not apparent who has ties with whom; an interesting question becomes how to recognize a network structure that has many opportunities to span structural holes without having a complete overview of the network. However, the fact that we found diminishing returns suggests that a firm does not have to monitor the complete network in order to find an efficient network position.

Network horizon is a dynamic construct, the information a firm has of the network can increase or decrease over time. New sources of information are tapped into by establishing new non-redundant ties that in turn will increase the available information about the network structure, while disbanding ties will result in a loss of information about the network structure. Firms can decide to invest more time and energy in monitoring the network and thereby expanding the information they have about the network structure. By bringing in a firm construct (network horizon) in the explanation of network structure properties and the explanation of network structure emergence, we move away from a pure structuralist perspective (Emirbayer & Goodwin, 1994) and take into consideration firm attributes. In the next chapter, we will focus on how long a firm can benefit from its bridging position.

5 The Sustainability of Bridging Positions

In the previous chapter, we focused on the effect of network horizon on the network position. In this chapter[35,36], we will focus whether firms are able to benefit longer from a particular network position due to their network horizon.

Why are some firms able to sustain their competitive advantage longer than others? For resources owned or controlled by the firm, the resource-based view (RBV) gives a clear answer: the firm's resources should be valuable, rare, inimitable and imperfectly substitutable (Barney, 1991). However, when the sources of competitive advantage reside outside the boundaries of the firm (Dyer & Singh, 1998), the situation becomes less clear (Lavie, 2006). In a networked environment, firms can obtain the benefits of resources from partners without controlling the resources themselves and so can other firms for the same resources, which makes the inimitability and imperfect substitutability conditions of the traditional RBV less applicable (Lavie, 2006). At the same time, the burgeoning literature on the effects of network position on performance suggests that certain network positions can confer at least a temporary competitive advantage (Burt, 1992; Powell et al., 1999; Zaheer & Bell, 2005), especially due to its complex, causally ambiguous nature (Wilcox King, 2007). Furthermore, empirical observation shows that networks change (Baum et al., 2003; Powell et al., 2005), not just through exogenous events (Madhavan et al., 1998), but also endogenously as a result of purposeful firm action to improve their position and achieve a competitive advantage. For instance, studies in the airline and telecommunication industries show that firms respond to alliances of competitors by announcing alliances of their own aimed at countervailing the effects of the competitors' alliances (Gimeno, 2004; Gulati & Singh,

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[35] A previous version of this chapter was presented as a paper by van Liere, D. W. 2006. ***The Life Span of Structural Holes***. Paper presented at the Academy of Management, Atlanta, GA.

[36] This chapter is currently available as a working paper at the Social Science Research Network: van Liere, D. W., & Koppius, O. R. 2007a. Network Horizon and the Sustainability of Network-Based Competitive Advantage. ***Working Paper at SSRN***. Available at: http://ssrn.com/paper=963040.

1998). Given these and other network dynamics, how can we then explain the sustainability of bridging positions?

In this chapter, we offer one possible explanation. The departure point of our explanation is that in order to achieve competitive advantage, firms need to have accurate expectations of future resource value (Barney, 1986), because such information is crucial for discerning entrepreneurial opportunities (Burt, 1992; Kirzner, 1997; Ozgen & Baron, 2007). In a networked setting, entrepreneurial opportunities for competitive advantage are presented by occupying certain specific network positions in the overall network structure (Burt, 1992; 2000). Thus, having information about the network structure enables a firm to locate and obtain valuable network positions (Gulati & Gargiulo, 1999) before others do and potentially achieving a competitive advantage. We therefore introduced the construct of *network horizon*, in Chapter 2, that describes the information that a firm has about the network structure it is embedded in (a more formal definition will follow in a subsequent section). We expect firms with an extensive network horizon to be able to maintain their favorable positions longer. Furthermore, since firms in general can be expected to differ in their expectations of future resource value (Makadok & Barney, 2001), specifically in a network setting this implies that different firms will have different network horizons. These information differences will translate into different entrepreneurial opportunities being perceived (Denrell et al., 2003), and hence firms with different network horizons will strive for different network positions. The resulting dynamics are likely to affect the sustainability of firms' network positions, and we therefore introduced the construct of *network horizon heterogeneity*, in Chapter 2, which describes how the network horizon differs across firms (a formal definition will follow in a subsequent section).

Previous work on the dynamics of network position suggests that firms may shift their position for instance due to resource dependence motives (Pfeffer & Salancik, 1978), competitive pressure (Bae & Gargiulo, 2004) or competition within (Gimeno, 2004) or between networks (Gomes-Casseres, 1996). These changes in the network structure reflect competitive dynamics between firms that are pursuing a competitive advantage. All of these explanations have the assumption in common that firms are aware of the changes in the network, have information about their potential partner firms and detect opportunities in the network to shift their network position. Investigating what happens when we allow for interfirm differences in this information assumption is the focus of this chapter. This is also what differentiates us from recent research that looked at the dynamics and sustainability of network positions – structural holes in particular – (Bala & Goyal, 2000; Buskens & van de Rijt, 2005; Sorenson & Ryall, 2007), who investigate different influences on network dynamics, but assume that all actors have complete information of the network. Our focus on information in the form of network horizon and network horizon heterogeneity can add substantial empirical and theoretical insight to this emerging literature for three reasons. First, we have a limited understanding to what extent organizational-decision makers are actually aware of the networks their firms are embedded in (Rowley & Baum, 2004), so modeling this information aspect is a step towards increased empirical fidelity of the model. Second, awareness and information about the network structure is important because it is a first prerequisite to respond to or anticipate changes that will affect firm strategy (Chen, 1996; Daft & Weick, 1984). Third, the dynamics through which interfirm networks change over time are not yet very well understood (Baum et al., 2005; Gnyawali & Madhavan, 2001), and network horizon (heterogeneity) can shed light on how firms come to obtain or maintain a particular network position and hence sustain their network-based competitive advantage.

We employ a computational model of network dynamics to formalize our intuitions. Results from a series of controlled experiments indicate that sustainability of a bridging position is increased by having a more extensive network horizon, especially under conditions of high network horizon heterogeneity. In networks with low network horizon heterogeneity, the majority of firms experience lower sustainability overall, especially when the average network horizon is high. These findings suggest that an explanation for the sustainability of a bridging position can be found in the firms' network horizon.

The remainder of this chapter is organized as follows: in the next two sections, we describe the theoretical background behind network positions and the network horizon construct and we formulate our propositions. Subsequently, we describe the computational modeling environment we use to formally model the effects of network horizon and network horizon heterogeneity on the sustainability of a bridging position, as well as the design of our computational experiments. Next, we illustrate the results of these experiments, finding broad support for our propositions. The discussion and future research section concludes by highlighting the implications of our findings for the resource-based view of networked organizations and network theory and we close with suggesting some empirical strategies for researching the scanning activities of a firm in a business network environment.

5.1 Network Position and Competitive Advantage

The benefits of network positions have received considerable attention in the strategic management literature. Network positions confer an advantage to a firm by providing access to valuable and scarce resources (Burt, 1992; Dyer & Singh, 1998; Gnyawali & Madhavan, 2001; Maurer & Ebers, 2006; Pfeffer & Salancik, 1978; Pollock et al., 2004). The configuration of the set of interfirm relationships with other firms determines the network position that a firm occupies. Two well known and often studied network positions are the bridging position (Burt, 1992; 2000) and the closed or dense position (Coleman, 1988). A firm occupies a bridging position when its partner firms are not directly connected to each other, i.e. there are structural holes (Burt, 1992) between the partner firms. Contrary, a firm occupies a closed position when its partner firms are directly connected to each other, i.e. there are no structural holes between the partner firms. The mechanisms by which these two types of network positions create value are orthogonal. The bridging firm creates value by exploiting information asymmetries between its partner firms such as information and control benefits (Burt, 1992) while a firm occupying a closed position creates value by reducing information asymmetries and thereby creating effective sanction mechanisms (Coleman, 1988), shared mental maps that facilitate knowledge transfer (Dyer & Nobeoka, 2000) and effective reputation mechanisms (Coleman, 1988). Although both types of positions have their respective merits (see for an extensive review Burt (2000)), in this chapter we will focus exclusively on bridging positions because previous research suggests not only that bridging positions are an important source of value creation (Burt, 2000) but simultaneously decay at a high rate (Burt, 2002). Particularly this dynamic aspect of bridging positions as a type of network position that can confer competitive advantage[37], makes it well suited for studying the sustainability of network positions. Closed positions by their very nature are much more stable (Rowley et al., 2005) since they depend on strong ties that take time to form and hence they are less suited as a baseline starting point. Having said that, focusing

[37] In line with findings from the extensive empirical literature on structural holes, we will abstract away from issues that may prevent the exploitation of a structural hole, for instance when concerns for trust among actors are paramount (Ahuja, 2000), and assume that occupying a bridging position is sufficient for a competitive advantage (although not necessarily sustainable).

only on a single type of position constitutes a limitation of our model, although the model developed here can serve as a useful baseline for more complicated models, in particular those where firms can pursue bridging positions as well as closed positions or hybrid positions (Baum et al., 2006).

5.2 Network Horizon and Dynamics of Network Positions

Given that a network position such as a bridging position can confer significant benefits, the question arises how firms get to such positions and how they get there before others do. While luck and serendipity may play a role in recognizing valuable opportunities (Barney, 1986; Denrell et al., 2003), firms also actively scan the environment for information about opportunities (Daft & Weick, 1984). Studies have shown that more frequent and broad environmental scanning improves overall performance (Daft et al., 1988) and that specifically scanning for market information and competitor information is particularly important for sales growth in highly dynamic environments (Garg, Walters, & Priem, 2003) as this allows firms to quickly jump on new market opportunities (Ozgen & Baron, 2007).

In a network setting, new market opportunities can be presented by opportunities to act as a bridge between two otherwise disconnected actors, i.e. fulfilling a brokerage role (Burt, 1992; Fernandez & Gould, 1994; Sorenson & Ryall, 2007), which generates control benefits and information benefits that can lead to competitive advantage. Recognizing and exploiting such structural holes requires accurate information about the network structure. The example in the top row in Figure 5-1 illustrates this.

In the top row (example 1), firm A spans a structural hole between firm B and firm C (situation t=0). Assume that firm B is aware of firm D but firm C is not, and that firm B perceives a profitable opportunity to act as a bridge between firm A and firm D. Firm B therefore decides to strengthen its network position by establishing a relationship between firm A and firm D (situation t=1). The consequences of this partnering decision are that the network position of firm B strengthens because of the additional brokerage opportunity, resulting in competitive advantage, but the network positions of firm A and firm C remain unchanged and the competitive advantage deriving from the bridging position of firm A remains sustained[38].

[38] Theoretically speaking, the definition of sustainable competitive advantage is independent of the actual time that the competitive advantage was enjoyed, as it is only determined by whether or not the advantage may be duplicated by competitors (Barney, 1991, p.102-103). While we accept

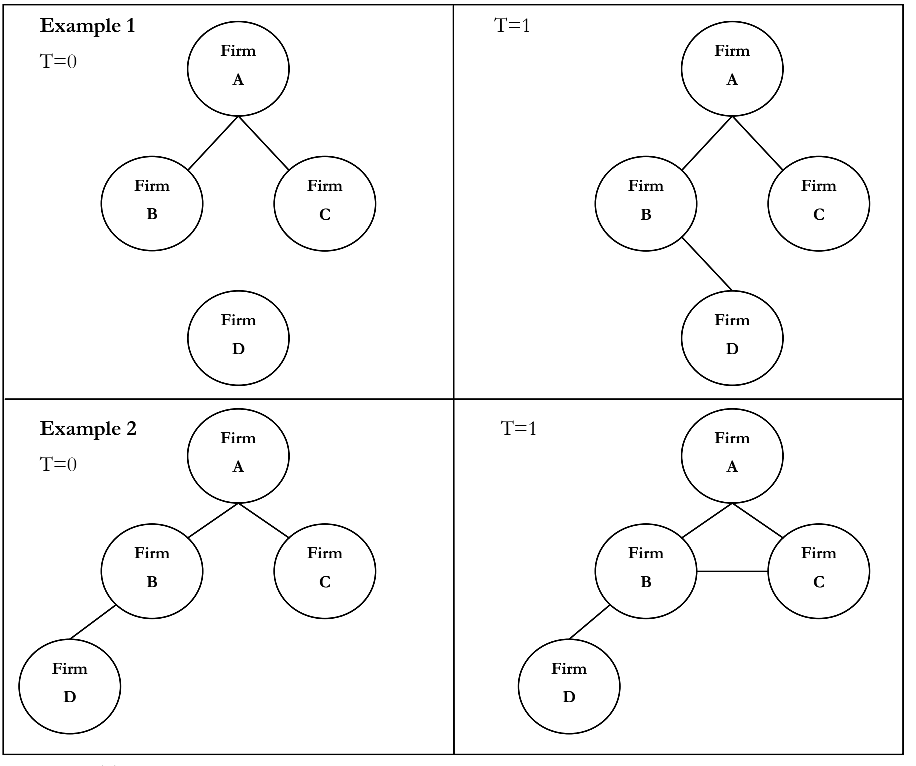

Figure 5-1 Two examples of the competitive dynamics of bridging positions

Thus, differences in information about the network structure translates into different opportunities being perceived, which in turn impacts the network positions that firms will occupy. Even though the notion of having information about the network structure is often acknowledged (1995b; Gulati & Gargiulo, 1999), it has received little theoretical or empirical attention. Or as Rowley and Baum (2004: 120) phrase it: "The idea that managers are aware of their firms' networks and the types of positions that provide social capital advantages – core assumptions underpinning the network strategy perspective – remains largely unexplored". Most studies thus far either assume that all firms know only their direct alters (Cook & Emerson, 1978; Cook et al., 1983) and nothing beyond that, or that all firms know the structure of the entire network (Skvoretz

this theoretical point, from an empirical point of view it is difficult to establish whether or not a given competitive advantage is sustainable, because that assessment is based on a *possible* (and hence unobservable) action of duplication. We therefore take a pragmatic approach and define a competitive advantage as sustainable if it remains in existence and focus on factors determining longer or shorter periods of sustainability.

& Willer, 1993). In reality, given limited resources available for environmental scanning (Peteraf & Bergen, 2003), it is likely that a firm only has information on a subset of the overall network structure. This information is what we referred to as a firm's *network horizon*[39].

5.2.1 Consequences of network horizon

Firms with an extensive network horizon thus know more other firms in the networks and have more information about the network structure. Hence, they are more likely to perceive profitable brokerage opportunities and achieve competitive advantage. Occupying a bridging position has other benefits as well. As Gulati and Gargiulo (1999) argue, the current interfirm network functions as a repository of information about partner firm's capabilities, behavior and network structure. How a firm is embedded in the network is an important determinant how fast a firm will receive information. Burt (Burt, 1992) calls it the timing benefit. Network horizons being equal, firms occupying bridging positions will know sooner about potential opportunities in the network and thus have an advantage in shifting their network position compared to firms that do not occupy bridging positions. This implies that although bridging position decay (Burt, 2002), the accompanying information benefits mean that a firm in a bridging position can quickly replace lost opportunities with new ones, maintaining its favorable bridging position. A more extended network horizon thus has the twin benefits of not only being able to occupy a stronger bridging position (i.e. more structural holes) but also a greater

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[39] The formal definition of network horizon has been introduced in Chapter 2 and 4, here it is repeated for convenience. To formally define network horizon, let the network be modeled as a graph G = (V, E); consisting of a vertex set V (the firms) and an edge set E (the ties between firms). Let d(u,v) be the geodesic distance between firms u and v, i.e. the smallest number of ties that need to be traveled to reach v from u. The k-neighborhood of firm u is then defined as:

$$N_k(u) = \{v \in \mathrm{V} \mid \mathrm{d(u,v)} \leq \mathrm{k}\}$$

In other words: the k-neighborhood of u consists of all firms v that can be reached from u in at most k steps, including u itself. Firm u's network horizon is then defined as the percentage of firms of the total network that are in firm u's k-neighborhood, formally stated: $NH_k(u) = \frac{|N_k(u)|}{|V|} * 100\%$, where $|N_k(u)|$ and $|V|$ denote the number of firms in u's k-neighborhood and V respectively and we will say that v is *within* u's network horizon when $v \in N_k(u)$.

sustainability of that position, although extending the network horizon further is likely to exhibit decreasing marginal returns as the most profitable opportunities are likely to have been taken already. We thus have the following proposition:

> *Proposition 1*: The more extensive a firm's network horizon, the more likely a firm will sustain its bridging position[40].

The previous section focused on how a focal firm's network position is influenced by its own network horizon and its actions, but a firm's network position is also determined by the actions of the other firms in the network, in particular its alters. The second row in Figure 5-1 provides an example: here, firm A spans a structural hole between firm B and firm C and Firm B spans a structural hole between firm D and firm A. Firm B is aware of firm C and perceives a profitable brokering opportunity between C and D. Therefore, at t=1, firm B decides to establish a tie with Firm C (who agrees to the tie). The effect of this partnering decision is that the strength of the bridging position of firm A decreases because the structural hole between firm B and firm C is 'closed', as an alternative path is now available to connect firm B to firm C. Simultaneously, a new structural hole has been spanned, firm B is the bridging firm between firm D and firm C. The consequences of this partnering action are that the bridging position of firm B strengthens at the expense of the bridging position of firm A, hence the competitive advantage of firm A's previous position is not sustained.

In this example, firm B established a tie with firm C because it represented the most profitable opportunity of the potential firms within its network horizon. Had firm B's network horizon been more extensive, then ceteris paribus firm B would have had more potential opportunities to choose from (unless the entire network was already within firm B's horizon), lowering the probability that firm C would have been chosen, hence increasing the probability that firm A's bridging position and competitive advantage would have been sustained. The argument from this example that more choice options for a firm's alters benefits the focal firm, is stated as the following proposition:

[40] In this chapter, we will use propositions instead of hypotheses, which is in contrast with Chapter 4 and Chapter 6. The reason is that in Chapter 4 and 6 the hypotheses are tested using statistical techniques while in this chapter such relationships are not formally tested.

Proposition 2: The more extensive the network horizon of a firm's alters, the more likely a firm will sustain its bridging position.

5.2.2 Network horizon heterogeneity

A focal firm's direct alters are not the only actors that can influence its network position, obviously other (non-alter) firms can do so as well but this depends on their network horizons. As argued previously, firms are likely to differ in their ability and efforts to collect information about their environment and the opportunities they recognize (Daft et al., 1988; Denrell et al., 2003; Makadok & Barney, 2001), i.e. different firms will have different network horizons. At the network level, this creates a distribution of network horizons over the different firms in the network, and this distribution determines the *network horizon heterogeneity* of the network. There are multiple ways to conceptualize this heterogeneity, each with different underlying theoretical rationales (see Klein & Harrison (2007) for more detail on the different ways). The underlying attribute that is heterogeneous (network horizon) represents a socially valued asset or resource of the firms, the appropriate conceptualization is of the disparity-type, which can be measured by the inequality or relative concentration measures such as the Gini-coefficient or the coefficient of variation (Klein & Harrison, 2007). We opt for the Gini-coefficient (Weisstein, 2006), which results in the following definition of network horizon heterogeneity (NHH) for a given network G (V,E):

Definition 24: $$NHH(G) = \frac{\sum_{u \in V} \sum_{v \in V} \left| NH_k(u) - NH_k(v) \right|}{2|V|^2 \mu}$$

where μ represent the average network horizon of all actors in G. A network horizon heterogeneity value of zero indicates that there is perfect equality of the network horizons among the different firms. A value of one indicates that there is maximum inequality: one firm has information about the whole network structure and the other firms do not have any information.

These four combinations result in different levels of network horizon heterogeneity and hence different possibilities for the focal firm to compete for bridging positions. A focal firm with an extended network horizon, in a network with a heterogeneous distribution of network horizons is able to sustain its network position longer since the limited network horizon of non-focal firms implies a lack of information regarding the potential location of structural holes and these firms are not able to compete for structural holes. This implies that the focal firm's position is more likely to be sustained. If the focal firm has a limited network horizon and the non-focal firms have an extended horizon, the focal firm will find itself in a disadvantaged position, as its network position is largely dependent on the actions taken by the non-focal firms.

Network Horizon	**Focal Firm** **Limited Network Horizon**	**Focal Firm** **Extensive Network Horizon**
Non-Focal Firms **Limited Network Horizon** **(all identical)**	The network structure has potentially many opportunities for brokerage but these opportunities are not recognized because of the inability of firms to locate them.	The focal firm is able to improve its network position and the sustainability of the position is expected to be long because the competition for favorable network positions is small due to the inability of the non-focal firms to locate brokerage opportunities.
Non-Focal Firms **Extensive Network Horizon** **(all identical)**	The focal firm is disadvantaged in shifting its network position while the non-focal firms are advantaged.	Competition for favorable network positions is intense and many opportunities are recognized but their sustainability is short.

Table 5-1 Network horizon heterogeneity and impact on the sustainability of network positions

Hence, the focal firm is not able to participate in the competition for bridging positions, and there is no possibility of sustaining the bridging position. In a network with a homogeneous distribution of horizons and all firms having a limited network horizon, the focal firm does not have many opportunities for improving its bridging position, but so do its alters, which implies that any competitive advantage that the focal firm might have, although probably small, is likely to be sustained longer than under a heterogeneous network horizon. If on the other hand the network is homogenous and all firms have a high network horizon, all firms are quickly able to spot any possible opportunities for improving their position, no matter how small, and any competitive advantage that the focal firm might have, is likely to be duplicated quickly and hence not sustainable. This argument in stated in the following two propositions:

Proposition 3: The higher the network horizon heterogeneity, the more sustainable a bridging position will be.

Proposition 4: The effect of network horizon on the focal firm's sustainability of its bridging position will be moderated by network horizon heterogeneity: the higher the network horizon heterogeneity, the larger the effect of network horizon.

5.3 Methodology – Computational Model

We use a computational modeling approach to investigate our propositions. We decided to use a computational modeling approach because our research question calls for studying longitudinal processes with interacting between many heterogeneous actors, which makes analytical tractability of the model difficult. Furthermore, a computational model allows us to experiment with a wide range of settings which fosters the development of new theory (Davis et al., 2007). The computational model is built using software agents. In the terminology of Davis et al. (2007) is our computational model an example of a stochastic process model.

Agents are autonomous entities in a software environment that perceive and act upon their environment (Wooldridge, 2000). An individual agent can be described using the 'beliefs-desire-intentions' model (Bratman, 1987). According to this system, an agent is modeled to have some information about its environment (beliefs), an agent pursues a certain state (desire), and an agent has a repertoire of actions (intentions) it can take to try to realize its desire. In our computational model, we modeled firms as agents. Each firm has a network horizon as its belief, the network position it pursues is its desire and the ability to form or terminate relationships are its intentions.

5.3.1 Model

Our overall model setup closely follows the actor-driven model of network dynamics developed by Snijders (2001), although with a more simplified utility function. In our computational model, we assign each firm in our network two characteristics: 1) a utility function (which is identical for all the firms in the network) which states that each firm tries to span as many structural holes as possible given its network horizon and 2) a network horizon (which can differ between firms). In other words, firms are homogeneous in every aspect except their network horizon, which allows us to study the effects of network horizon (and network horizon heterogeneity) in isolation of all other factors that influence the sustainability of competitive advantage. The utility function *U* for firm *i* at time *t* is modeled as:

$$U_{i,t} = \sqrt{\sum_{j_t}\left[1-\sum_{q} p_{iq}m_{jq}\right]*\sum j_t, q \neq i, j_t}$$

A network position is defined as being sustainable when $U_{i,t} - U_{i,t+1} >= 0$. Therefore, as long as a firm is able to maintain or improve its current utility then the network position is considered sustainable (see also footnote 38).

Sum *j* is the set of partner firms (alters). p_{iq} is the proportion of *i*'s network time and energy invested in the relationship with *q* and m_{jq} is the marginal strength of *j*'s relation with contact *q* (Burt, 1992: 51).

$$p_{iq} = \frac{(z_{iq} + z_{qi})}{\left[\sum_{j}(z_{ij} + z_{ji})\right]}, i \neq j \text{ and } m_{jq} = \frac{(z_{jq} + z_{qj})}{\max(z_{jk} + z_{kj})}, j \neq k$$

z_{jq} is the network variable measuring the strength of relation j to q (Burt, 1992: 51). We use Burt's (1992) effective size measure, multiply by the degree, and take the square root. We use effective size because it is a measure of non-redundancy of a network, less redundancy means a stronger bridging position.

To model the costs that are associated with establishing and maintaining ties we multiply the effective size by the degree and take the square root of the total sum to model these costs. We then define a threshold utility level by multiplying this formula with 1.10, the substantive interpretation being that the increase in utility should be at least 10% in order for the benefits of the tie to outweigh its costs[41]. Thus, a new tie will only be established when there is a reasonable utility increase. We model network horizon using its *k* network neighborhood as defined earlier. In our model, we choose k=2 because that is consistent with Friedkin's notion of horizon of observability (1983) who found that individuals have a great difficulty in accurately perceiving the network beyond two steps. Lant and Baum's (1995) found that firms only pay attention to close competitors but tend to ignore hardly more distant competitors and Gulati and Gargiulo's (1999) found that firm's alliance partners tend to come from their partner's alliance networks. In addition, we initialize the network horizon at the start of the simulation with a set of fixed size of randomly chosen actors (the size will be varied later in the experimental design) that accounts for other sources of information about actors

[41] Sensitivity analysis shows that changing this value to 5% or 20% would result in networks with properties that are more removed from empirical interfirm networks (see the 'Validation' section) than the chosen value of 10%.

in the network priori to network dynamics taking place. Table 5-1 gives an overview of the model parameters and the theoretical foundations.

Parameter	Theoretical Construct	Representation in Model
Initial network structure	To prevent bias from the initial network structure we create an initial network with no ties.	A completely unconnected graph; e.g. the graph consists only of isolates.
Network position	A firm will pursue a bridging position	Utility function $U_{i,t}$.
Cost of ties	We use a threshold to calculate whether the improvement of the utility is significant or not. A non-significant improvement of the utility means that the tie will not be established.	The utility improvement is set at 10%.
Network horizon (firm level)	A firm has information of a *k* network neighborhood.	*K* is set at two which follows the suggestion by Friedkin (1983).
Random term	Captures other processes that could be responsible for transfer of information about the network structure.	Poisson distribution with values α.
Network horizon heterogeneity (network level)	We use discrete but varying distributions of the random term to create different initial levels of network horizon heterogeneity.	To explore the parameter space we choose as values for network horizon heterogeneity: 0.00, 0.25, 0.50, and 0.75.

Table 5-2 Theoretical foundations of the computational model

5.3.2 Partnering algorithm

At the start of the model we generate a graph G with one hundred nodes and zero edges, this graph effectively consists of only isolates. We do this for two reasons. From a methodological standpoint, it prevents bias from the initial starting graph because the network position of each firm is non-existing. From a theoretical point of view, an empty graph can be thought of as the birth of a new industry, which is characterized by the entrance of incumbent firms and the birth of start-ups.

Each firm knows the subgraph defined by its network horizon, see also Chapter 2, i.e. $G[NH_k(u)]$, the subgraph that consists of the alters of the focal firm and the firms the focal firm already knew at the start of the simulation due to the initialization of network horizon. This subgraph $G[NH_k(u)]$ is used to compute the current utility a firm has (using $U_{i,t}$), as well as utility improvements by establishing new ties to $G[NH_k(u)]$.

We run the model for twenty-five cycles (including t = 0) for each experimental setting. During one cycle each firm can instantiate a new relationship, after all firms have tried to improve their network positions the next cycle starts. A firm is randomly chosen at the start of each cycle, which we call firm u. For each firm in the sub graph $G[NH_k(u)]$, firm u will calculate its utility improvement if it established a tie with a firm from the sub graph $G[NH_k(u)]$. Firm u chooses the relationship that has the highest utility improvement. Note, although a firm expects that its utility will increase based upon its incomplete understanding of the network structure, the actual result might be a smaller utility improvement or even a loss of utility. This is illustrated by the following example (see Figure 5-1 - example 2). If at t = 1 firm D is not aware of the relationship between firm B and firm C and firm D would establish a tie with firm C, then firm D believes it is spanning a structural hole between firm B and firm C while in fact firm D is weakening the bridging position of firm B.

The partnering algorithm continues as firm u proposes to establish a tie with firm v. An important design assumption of our computational model is that it is based on a cooperative network formation assumption (Watts, 2001) that requires that a link is only established when both actors agree. Severing a relationship remains a unilateral decision. Although this assumption may not apply to all networks (e.g. in citation networks the link is unilaterally established), we believe it is a reasonable representation of firm behavior in most interfirm networks. After receiving the proposal from firm u, firm v then calculates its improvement using its own utility function. If firm v's utility improves as well and firm v perceives the utility improvement to be above the threshold value then firm v accepts the proposal and a tie is created, else firm v will reject the proposal and no tie will be created. During each cycle of the computational model, a firm can initiate only one action (although it can be the recipient of and accept multiple tie proposals). Should firm v for instance decline firm u's tie proposal, then firm u cannot propose another relationship with another firm. It will have to wait until the next cycle to propose to another firm. This entire sequence is repeated for each firm in the network and then the next cycle starts. Although the partnering decisions are sequentially computed, we treat the partnering decisions as a simultaneous process because during a cycle the network horizon of the firms is not updated. Modeling the partnering process as a simultaneous process prevents first-mover advantages. Figure 5-2 summarizes the algorithm in a process flow diagram.

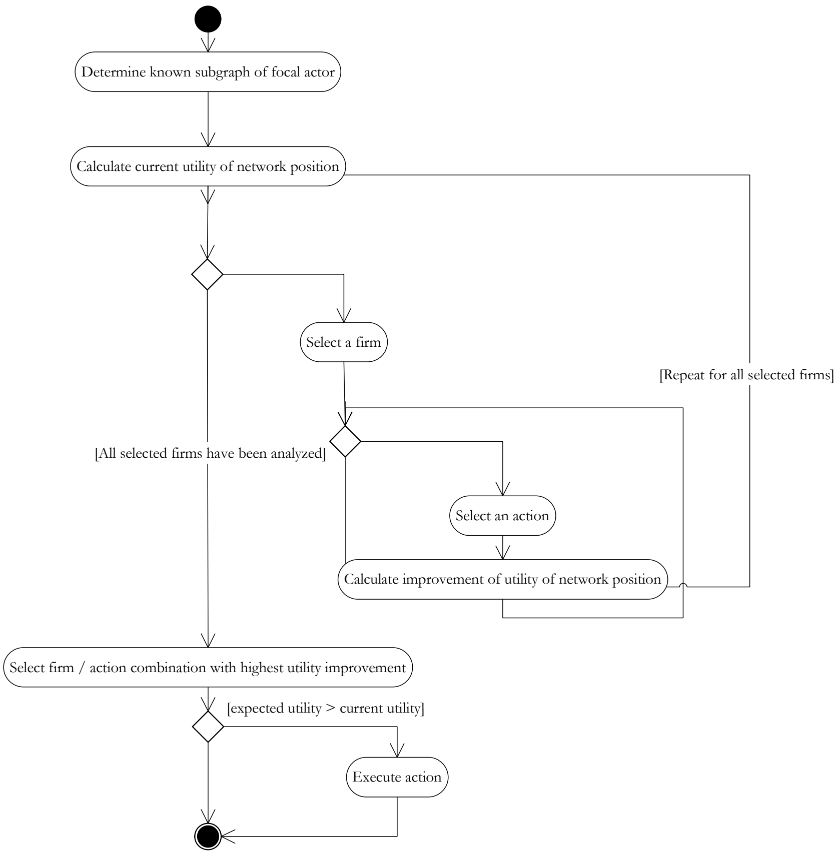

Figure 5-2 Process flow diagram of the partnering algorithm

Once a firm is not able to exceed its threshold utility, it will choose to terminate the least valuable tie in order to free resources to create a new tie. Although the establishment of a tie implies that new firms may appear within both firms network horizon if the distance is two or less, the network horizon of the firms is not updated immediately during a cycle. We theoretically model the firms as if they are simultaneously strengthening their bridging position but for computational reasons we sequentially loop through the firms and update each firm's network horizon at the end of a cycle.

5.3.3 Experimental setup

We ran fifteen different experimental settings with the computational model of 100 firms. For sake of simplicity, we use two groups of firms each with a different network horizon. In the first four sessions, we keep the network horizon heterogeneity constant at 0.00 and increase the initial network horizon from 5 firms (5% of entire network structure is known to a firm at the start of the experiment because the graph consists of only isolates the *k* network neighborhood is empty) in session 1 to 10, 25 and 50 firms (50% of entire network structure is known to a firm) in sessions 2-4. Theoretically, this variation models how well entrants in a new industry know other players in the industry due to prior knowledge. To take an example from Makadok & Barney (2001), the dawn of the personal computer industry was characterized by the entrance of a variety of established firms like mainframe manufacturer IBM, consumer electronics firm Atari, electronics retailer Tandy, but also the genesis of de novo firms such as Apple. Given this diversity, these firms presumably entered with limited knowledge of other players in this new field. As an illustration from the other side of the spectrum, the firms that first entered the semiconductor industry were all founded by people who were familiar with one another from a series of technical seminars at AT&T Bell Labs in the early 50s (Holbrook, Cohen, Hounshell, & Klepper, 2000), and were thus presumably quite aware of the players in the field.

In the next four sessions (session 5 to session 8), we keep the network horizon heterogeneity constant at .25 and run a session with average network horizon of 5%, 10%, 25% and 50% (to replicate the first four sessions). We configured session 9 to session 12 have an initial network horizon heterogeneity of .50 and session 13 to 15 have an initial network horizon heterogeneity of .75. Due to rounding errors, some sessions do not exactly match the initial values of the first four sessions. Fifteen different settings were configured; Table 5-2 gives an overview of the experimental setup.

Each network contains one hundred firms. Initially, a firm knows either 5%, 10%, 25% or 50% of the complete network through the assignment of the random term. The network horizon heterogeneity is either 0.00, 0.25, 0.50 or 0.75. We have chosen these values they cover the whole parameter space and therefore can be used to test their impact on the sustainability of a bridging position.

	Experimental condition $NHH_{s,t=0}$	Experimental condition average network horizon (at t=0)	Assigned random term group 1 (N is number of firms, α = random term)	Assigned random term group 2
Session 1	.000	5 firms		N = 100; α = 5 firms
Session 2	.000	10 firms		N = 100; α = 10 firms
Session 3	.000	25 firms		N = 100; α = 25 firms
Session 4	.000	50 firms		N = 100; α = 50 firms
Session 5	.250	5.47 firms	N = 93; α = 4 firms	N = 7; α = 25 firms
Session 6	.250	10.3 firms	N = 78; α = 7 firms	N = 22; α = 22 firms
Session 7	.248	25.28 firms	N = 86; α = 18 firms	N = 14; α = 70 firms
Session 8	.253	53.54 firms	N = 27; α = 17 firms	N = 63; α = 75 firms
Session 9	.521	4.99 firms	N = 87; α = 2 firms	N = 13; α = 25 firms
Session 10	.500	12.36 firms	N = 84; α = 5 firms	N = 16; α = 51 firms
Session 11	.499	25.28 firms	N = 63; α = 8 firms	N = 37; α = 72 firms
Session 12	.496	42.3 firms	N = 53; α = 9 firms	N = 47; α = 99 firms
Session 13	.751	6.39 firms	N = 89; α = 1 firm	N = 11; α = 50 firms
Session 14	.750	12.67 firms	N = 89; α = 2 firms	N = 11; α = 99 firms
Session 15	.745	22.56 firms	N = 78; α = 1 firm	N = 22; α = 99 firms
Session 16	It is not possible to have a network with 100 firms, average network horizon of 50 firms and network horizon heterogeneity of .75. This can only be achieved by increasing the network size.			

Table 5-3 Configuration of computational model

5.4 Analysis and Results

We will not conduct hypothesis testing in this chapter because the data was generated using a computational model and hence statistical testing is meaningless because we will find significant effects given enough replications. Before moving to the results regarding the sustainability of bridging positions, it is illustrative to show the influence of network horizon and network horizon heterogeneity on competitive advantage per se. Figure 5-3 shows the average utility (based upon the $U_{i,t}$ function) of a firm given different pair wise combinations of the network horizon of a firm and network horizon heterogeneity. The interpretation of this figure is as follows: a randomly selected firm with a network horizon of 10% (the firm is aware of 10% of the firms in the network) in a network with network horizon heterogeneity of 0.25 will have an expected utility of 1. The expected utility increases as we increase the network horizon (moving left along the left axis). This suggests that firms with a more extended network horizon are better able to detect brokerage opportunities in the network and hence are able to strengthen their bridging position. Firms with a moderate to high network horizon (30%-50%) and a high level of network horizon heterogeneity (>0.5) have a strong bridging position (expected utility is between 4 and 5). This illustrates that our starting point of network horizon being important for competitive advantage is plausible.

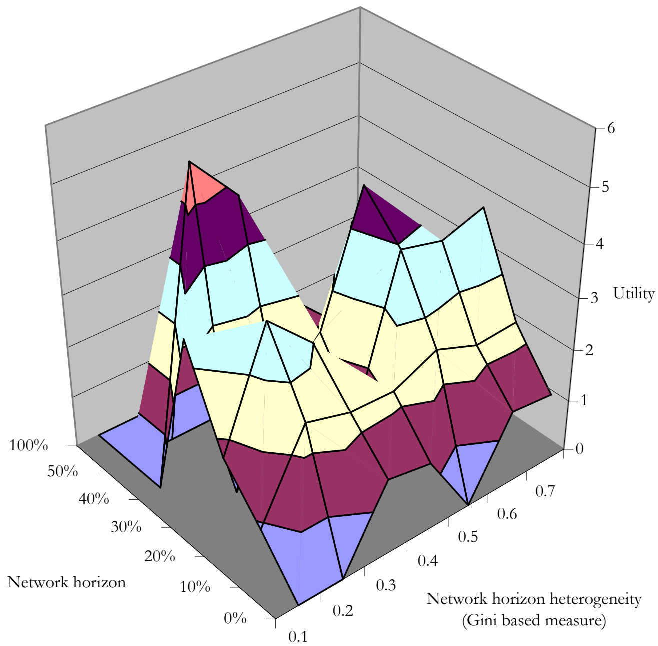

Figure 5-3 Network horizon (heterogeneity) and the strength of bridging position

We use figure 5-5 to assess the sustainability of a network position. For each firm in a particular network position, we calculated the difference in utility from t to t+1. As described in our model section, if this difference is positive, the network position at time t is considered sustainable. The z-axis (labeled utility) depicts the average of these cycle-to-cycle differences for each combination of network horizon and network horizon heterogeneity. A positive value indicates a sustainable network position while a negative value indicates an unsustainable network position. The first proposition stated that a firm will sustain its network position when the firm increases its network horizon but there are decreasing returns of the effect of network horizon on the sustainability of a network position. This effect is shown in Figure 5-4 on the right axis. As a firm increases its network horizon from 0 to 0.5 (with network horizon heterogeneity being zero), a firm is able to improve its utility, however this happens at a decreasing marginal rate as was formulated in proposition 1. Thus, the argument behind proposition 1 is corroborated by the results from the formal computational model.

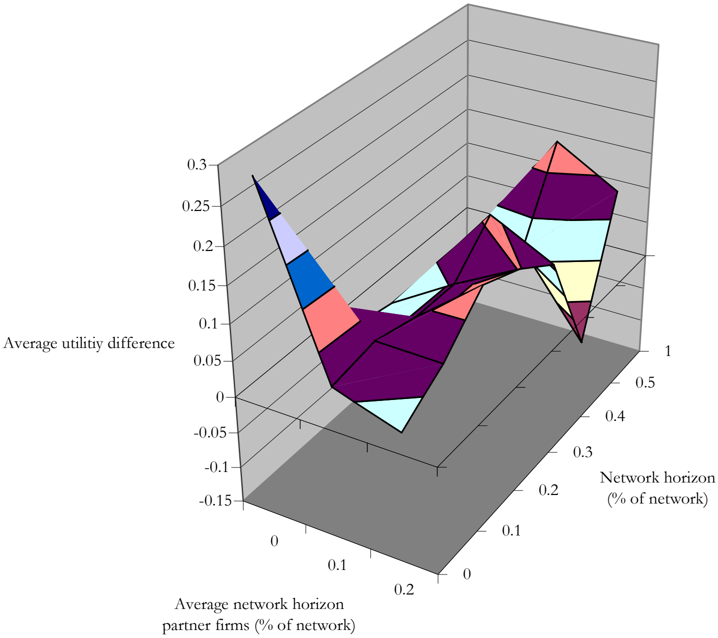

Figure 5-4 Focal firm network horizon, average partner firm network horizon and sustainability of bridging positions

The second proposition argued that as the network horizon of partner firms increases, the network position of the focal firm becomes more sustainable because those partner firms are less likely to partner with other partners of the focal firm. Instead, they will locate their own brokerage opportunities that do not have a detrimental effect on the sustainability of the network position of the focal firm. Figure 5-4 illustrates this effect. As the average network horizon of the partner firms increases from 0% to 20% the average utility difference of the focal firm increases over large sections of the network horizon axis, indicating the expected positive effect on sustainability. However, two regions are exceptions to this general conclusion. One, when the focal firms' horizon is lower than 10% the sustainability of the focal firm's network position decreases with an increase in average partner firm network horizon (although its network position remains slightly sustainable). This can be explained by the fact that partner firms are gaining a network horizon that is increasingly larger than that of the focal firm that has a detrimental effect on the sustainability of its network position (the lower left hand cell in Table 5-1). The second exception arises when the focal firm has an extensive network horizon of around 40%. As the average network horizon of partner firm increases, although still remaining lower than the focal firm's network horizon, at least some of the partner firms will detect the same set of brokerage opportunities and hence are pursuing the same network position as the focal firm. This results in increasing head-to-head competition and hence any competitive advantage is unsustainable (consistent with the lower right hand cell in Table 5-1).

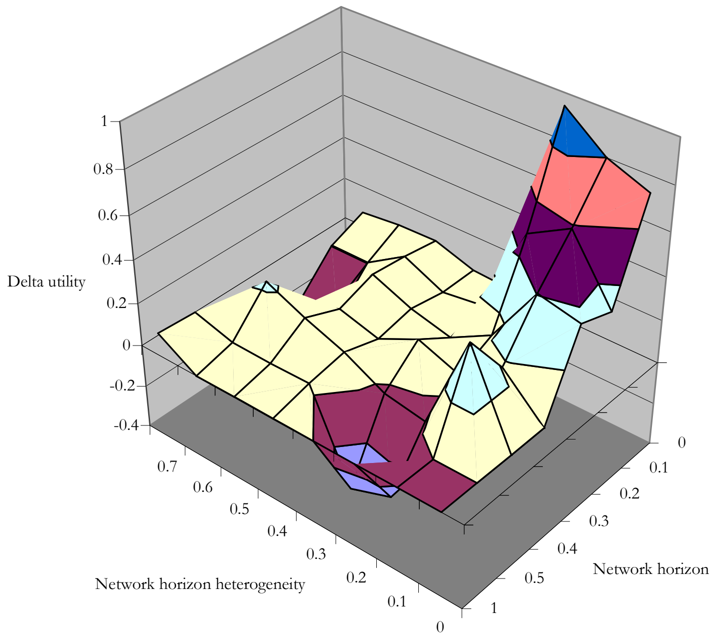

Figure 5-5 Network horizon (heterogeneity) and the sustainability of bridging positions

The third proposition stated that a network position of a firm becomes more sustainable as the network horizon heterogeneity increases. This effect is depicted on the axis labeled 'Network horizon' of Figure 5-5 (with network horizon is zero). This figure indicates that the sustainability of a network position increases as the network horizon heterogeneity increases, as the average utility difference (z-axis with delta utility) is positive. However, this effect diminishes as the network horizon heterogeneity passes the 0.4 value. This suggests that network horizon heterogeneity is particularly important for firms with a low to moderate level of network horizon (0% to 25%). This figure also illustrates what happens when many firms have an extended network horizon (network horizon is between 40% and 50%) and the heterogeneity is low (between 0.15 and 0.35). This is a situation where the competitive dynamics for a favorable network position are the strongest (this is the lower right hand cell in Table 5-1). Many firms detect favorable opportunities to improve their network position but none of the firms is able to sustain their competitive advantage. Even worse, on average firms will see their network position deteriorate and hence this is a situation where any competitive advantage is unsustainable.

The fourth proposition argued that a firm with an extensive network horizon would sustain its network position even longer when the network is characterized by a high level of network horizon heterogeneity. This can be seen in Figure 5-4 from the reversal of the slope along the network horizon axis between low and high network horizon heterogeneity: in a heterogeneous network, expanding the network horizon is increasingly beneficial as the sustainability increases. In a homogenous network (low heterogeneity) expanding the network horizon decreases sustainability and although sustainability remains positive for moderate levels of network horizon, it becomes negative for high network horizon, again ending up in the head-to-head competition observed previously (lower right cell Table 5-1).

Taken together, these findings suggest that firms are faced with a network variant of the tragedy of the commons: for each individual firm an increase of the network horizon is generally beneficial for the sustainability of its competitive advantage. The resulting dynamic is that all firms end up in a homogenous network all with an extensive network horizon, which is precisely the network where competitive advantage is virtually unattainable.

5.5 Conclusion

The basis of competitive advantage is becoming an interplay of a firm's unique resource endowment and the position it occupies in the overall network structure (Shipilov, 2006; Zaheer & Bell, 2005). While previous interfirm research focused primarily on how a network position confers a competitive advantage, increasingly scholars call for attention to the processes by which a network position changes (Baum et al., 2005; Parkhe, Wasserman, & Ralston, 2006) and how this affects a firm's competitive advantage. Our study is positioned at the nexus of the resource-based view and network theory and we advance these literatures by introducing two new constructs that can help explain the sustainability of bridging positions. Starting from the notion that recognizing advantageous network positions is key to obtain and sustain a competitive advantage and that exploiting these opportunities requires information about the network structure, we introduced the network horizon, and network horizon heterogeneity constructs to model this information at the firm and network level. We demonstrated that the network horizon of a firm and the network horizon heterogeneity in a network are important determinants for the sustainability of a firm's network position and hence its competitive advantage. Our findings support Makadok and Barney observation (2001: 1623) that "the most fundamental type of asymmetry capable of generating competitive advantage are interfirm differences in skill at collecting, filtering, and interpreting information about the future value of resources".

First, network horizon has a positive influence on the ability of a firm to locate brokerage opportunities and thereby increasing the sustainability of the network position. However, our computational model suggests that there are decreasing returns to the completeness of information about the network structure. The ability to shift and sustain a network position are greater when a firm increases its network horizon from low to high values but the strength of this effect diminishes.

Second, the network horizon heterogeneity affects the sustainability of the competitive advantage of a network position as well. More homogenous distributions of the network horizon lead to stronger dynamics of network positions. In such networks, firms are more directly competing vis-à-vis each other and this has a negative impact on the sustainability of a network position. A more heterogeneous distribution of network horizon has a positive impact on the sustainability of a network position of the focal firm because there are fewer firms able to detect brokerage opportunities and are therefore less likely to threaten the network position of the focal firm.

Recent research in sociology, economics and strategy (Bala & Goyal, 2000; Buskens & van de Rijt, 2005; Sorenson & Ryall, 2007) has found that under certain assumptions the competitive advantage from a bridging position is not sustainable. By relaxing an assumption that is common to all three studies, namely that firms know the entire network structure, we provide a complimentary angle and our results indicate that under certain conditions a firms' competitive advantage can at least be temporarily sustained. Whether this represents equilibrium behavior or not is a question we leave open for further research. What we can say is that in any case the sustainability is fragile because the risk of a tragedy of the commons is real.

We see two main implications of the network horizon construct for both managers and researchers. First, our formal model demonstrates that network horizon and network horizon heterogeneity are important determinants of the sustainability of a network position. This suggests a fruitful addition to the resource-based view in order to deal with the special nature of network-based resources in explaining competitive advantage. Fully in line with the quote by Makadok and Barney (2001) at the beginning of this chapter, we view informational differences such as network horizon as fundamental to understanding interfirm differences in competitive advantage. Our findings also suggests that if we want to understand the dynamics of network positions and bridging positions in particular, network theory should incorporate informational differences among firms as a key explanatory construct.

Second, a key managerial implication stems from our finding that firms with more information are better equipped in shifting their bridging positions compared with firms that have less information. Recent research has raised the question to which extent structural holes represent the same information and control benefits (Reagans & Zuckerman, 2006). Some bridging positions contain more value (information and control benefits) 'buried' than in other structural holes. Or as Pollock et al. note "not all structural holes are equivalent and equally attractive" (2004: 51). Discerning the more valuable network positions from the less valuable network positions requires detailed information about the network structure that firms need to incorporate into their environmental scanning policies (Yasai-Ardekani & Nystrom, 1996).

Some of our design choices in our computational model have consequences for the generalizability of our findings. We address two limitations we consider particularly salient. A first limitation stems from the fact that we chose bridging positions as the context for formulating our propositions, as this is a setting where network positions are likely to exhibit considerable dynamics. However, networks can also exhibit inertia (Kim et al., 2006). In such networks, different kinds of dynamics and positions may become important that we have not explored in our study.

A second limitation of our study is that, although we attempted to keep our assumptions as realistic as possible, the model remains a stylized representation of interfirm networks. Therefore, our findings would greatly benefit from empirical replication, as we will discuss in Chapter 7.

6 Weakening of Bridging Positions: An Opportunity and Threat Based Explanation

This final empirical chapter[42] of this dissertation addresses the third and final research question: why do bridging positions weaken? We offer two complementary theoretical explanations why a firm's bridging position weakens. In the previous two chapters, we focused on the partnering decision of the focal firm and its network horizon. We demonstrated that the focal firm's network horizon allows it to strengthen its bridging position. We move our focus from the focal firm to its partner firms and investigate how the actions taken by partner firms affect the bridging position of the focal firm. The partnering decisions of partner firms can potentially affect the network position of the focal firm because networks are relational and changes in the network position of one firm have consequences for other firms in the network as well. We explicitly limit ourselves to opportunities and threats that have their origin in the interfirm network and do not consider the impact of threats or opportunities that emerge from the overall environment. For example, the introduction of a new technology or the deregulation of an industry is outside the scope of this chapter.

The first explanation is that bridged firms spot an opportunity to strengthen their network position at the expense of the bridging firm. We will refer to this explanation as the opportunity-based explanation. The second explanation is that bridged firms become too dependent on the bridging firm and this dependence constrains the bridged firm in its actions. Therefore, the bridged firm decides to reduce its dependence by initiating new relationships. We will refer to this explanation as the threat-based explanation. These two explanations are built based upon findings from Chapter 4 and Chapter 5, environmental scanning literature (Hambrick, 1982), resource dependence theory (Pfeffer & Salancik,

[42] The paper version of this chapter will be presented by van Liere, D. W., & Koppius, O. R. 2007b. ***Why Do Bridging Positions Weaken?*** Paper presented at the Academy of Management, Philadelphia, PA.

1978), and the competitive dynamics view (Chen et al., 2007; Chen, 1996; Chen et al., 1992).

We assume that the decision to establish a new relationship or to disband an old relationship is not a random process, but rather the result of a deliberate action of the firm to improve its current network position (Madhavan et al., 1998). If firms are improving their network position then there are two possible motives. First, a firm has become aware of the fact that there are alternatives to the current network position that create as much or more benefits compared with the current network position. For a firm to change its network position, it has to be aware of alternative firms to partner with. It is not possible for a firm to shift its network position without information about possible alternatives (as we demonstrated in Chapter 4). Second, a firm recognizes a threatening situation. For example, a firm has become either too dependent on its partner firms or too similar, which leads to increased competition. Such threats can be the incentive for the focal firm to start looking for new partner firms and to shift its network position in order to alleviate the dependence or increased competition.

Previous research on interfirm networks has predominantly focused on network effects rather than network processes. The differential benefits of network positions and the contingencies of these benefits have been an important theme in the interfirm network literature (Ahuja, 2000a; Burt, 1992; 2000; Walker et al., 1997). In particular, the debate has revolved around the benefits of bridging and closed positions. A bridging position is one between two unconnected firms (i.e. a sparse position) while a closed network position is one in which the partner firms of a firm are also connected to each other (i.e. a dense position). However, network processes such as the dynamics of network positions have received less attention (Moldoveanu et al., 2003). Interfirm network research has often adopted a cross-sectional approach that limits our understanding of the origins of these network positions and the reasons that network positions decay (Baum et al., 2003; Rowley & Baum, 2004; Salancik, 1995). Focusing on the dynamics of network positions is important because some initial research suggests that bridging positions decay at a high rate (Burt, 2002) but the reasons why this happens remain unclear. Studying the weakening of bridging positions is important for two reasons: 1) it will increase our understanding how firms may occupy these positions through their partnering actions and 2) it will shed new light on the sustainability of network positions.

Research on the benefits of network positions has focused on the focal firm that creates and appropriates the value that is created by a network position. For example, a bridging firm spans structural holes and these holes create information and control benefits (2006; Burt, 1992; Burt, 2000). Thus, the bridging firm creates value by occupying a structural hole rich position and the value created through the information and control benefits is appropriated by the bridging firm. Nonetheless, if certain network positions are more valuable than other positions and the value created is appropriated by the bridging firm then this creates incentives for the partner firms (i.e. the bridged firms) to shift their position *possibly at the expense* of the network position of the bridging firm.

Therefore, we move our focus from the bridging firm to the bridged firms and investigate how the partnering actions taken by partner firms affect the bridging position of the focal firm. The partnering decisions of partner firms can potentially affect the network position of the focal firm because networks are relational and changes in the network position of one firm have consequences for the network positions of other firms in the network as well. The objective of this study is to contribute to the causes and consequences of network based competitive advantage. Hence, the research question we seek to address in this chapter is: "Why does the bridging position of the focal firm weaken?"

In order to investigate why bridging positions weaken, we will adopt a multi-method research design (Brewer & Hunter, 1989). We choose to adopt a multi-method approach because it increases the internal and external validity of our results. We use both network experiments and a field study that are both situated in the insurance industry.

6.1 Motives for the Bridged Firm to Shift its Network Position

Recent network research is starting to consider partner firms' network position on focal firm performance (Baum et al., 2006) and individuals (Burt, 2007). For example, the Baum et al. study (2006) of investment banks shows that banks that are linked to banks who occupy bridging positions outperform banks that do not have such partners. Therefore, it is not only important to incorporate a partner firms' network position but also to start incorporating the changes in the network position of a partner firm too and to study how these change affect the network position of the focal firm. Bridging ties represent value by connecting otherwise disconnected regions of a network. These ties generate information and control benefits because different unconnected firms of firms in a network are reached and these firms have different information available to them in terms of diversity, volume and richness (Koka & Prescott, 2002). This includes information about potential partner firms because the network functions as a search and monitoring mechanism (Gnyawali & Madhavan, 2001) and firms rely on their network as source of information about potential partners (Gulati & Gargiulo, 1999; Li & Rowley, 2002). However, recent research suggests that bridging ties are short lived (Burt, 2002). In the organization Burt studied, bridges decayed at a rate of 90% per year.

A bridged firm has two disadvantages: it does not receive diverse information on a timely basis and it cannot counter balance the power of the bridging firm because the bridged firm is too dependent on the bridging firm. However, according to Reagans and Zuckerman (2006) the information and control benefits are based on different assumptions about partner firm characteristics. Information benefits accrue to the focal firm when the partner firms are heterogeneous because these firms differ and hence will have different information sources. However, this comes at the expense of control benefits because it is not possible to play off heterogeneous partners against each other because they provide different resources and hence do not compete with each other. Control benefits accrue to the focal firm when the partner firms are homogenous because the focal firm can play off homogenous firms against each other but this comes at the expense of foregoing the information benefits. Homogenous partner firms are less likely to have different information sources thus will provide the same information benefits. These two mutually exclusive assumptions (partner firms are homogeneous or heterogeneous) require different explanations when this leads to a weakened bridging position. First, we will develop the situation when the partner firms are homogeneous, next we will develop the situation when the partner firms are heterogeneous.

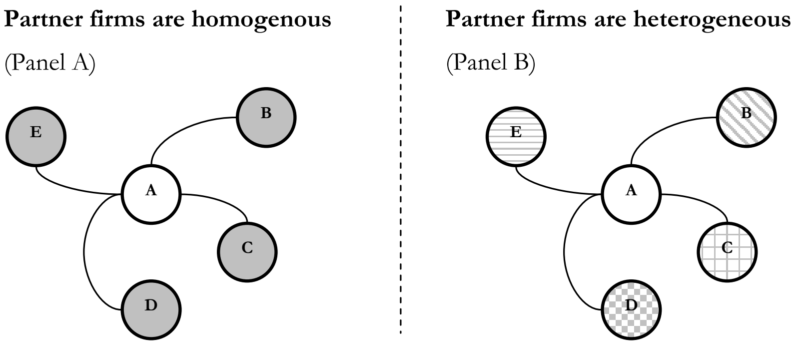

Figure 6-1 Illustration of homogenous vs. heterogeneous partner firms

However, both disadvantages (lack of control and lack of information) create an incentive for the bridged firm to shift its network position. We will theorize for both disadvantages why the bridged firm is likely to initiate new partnering decisions.

We start with the situation in which the partner firms possess homogeneous resources and capabilities (Panel A in Figure 6-1). This situation is detrimental for the bridged firm for two reasons. First, it gives the bridging firm the opportunity to play the similar partner firms off against each other. For example, suppliers possessing similar resources have a weaker bargaining position because the focal firm has more firms to choose from as the number of suppliers increases. Second, firms that have similar resources are experiencing higher levels of competition compared with firms that possess heterogeneous resources (Chen, 1996). The increased competition between the partner firms of the focal firm strengthens the focal firm's network position because it can dictate the terms of an exchange. A bridged firm can initiate new interorganizational relationships in order to lessen the competitive pressure and to weaken the bridging position of the focal firm. As a result, we hypothesize:

> *Hypothesis 1*: A bridged firm that possesses similar resources compared with the other partner firms of the focal firm at *t* leads to a weakened bridging position of the focal firm at *t+1*.

We now move to the situation in which the partner firms are heterogeneous (Panel B in Figure 6-1). This situation limits the potential for the focal firm to execute the *tertius gaudens* strategy (Burt, 1992). We refer to the *tertius gaudens* strategy when the focal firm is playing different firms off against each other. In order for the bridged firm to access new sources of information, capabilities or resources it needs to partner with new firms, preferably with firms from different groups parts of the network. The bridged firm gets access to new parts of the network through establishing non-local ties (Baum et al., 2005). As Burt (2000) noted, information between groups is more heterogeneous than within groups. Thus, establishing ties to these new groups is an efficient way of enlarging the pool of information or finding new capabilities and resources. To counterbalance the control benefits of the bridging firm, the bridged firm can partner with firms that provide (access) to similar capabilities and resources as the bridging firm. This is likely to happen in the case that the bridged firm is dependent on the bridging firm because the bridged firm will have more uncertainty about the input of its resources. Particularly, when these resources are critical for the survival of the firm or when these resources are needed in a great magnitude. Pfeffer and Salancik (1978) recognize this type of dependence and suggest that firms can unilaterally restructure their dependence. A unilateral action is, for example, when the bridged firm decides to partner with a new firm. Consequently, we hypothesize:

> *Hypothesis 2*: A high resource dependence of the bridged firm at *t* leads to a weakened bridging position of the focal firm at *t+1*.

In order for the bridged firm to access new sources of information, capabilities or resources it needs to partner with new firms, preferably with firms from different groups parts of the network. The bridged firm gets access to new parts of the network through establishing non-local ties. As Burt (2000) noted, information between groups is more heterogeneous than within groups. Thus, establishing ties to these new groups is an efficient way of enlarging the pool of information or finding new capabilities and resources. The bridged firm needs to have information about alternative partner firms to be able to establish non-local ties. The network horizon of a firm should expand beyond the ego network of the bridging firm to detect potential partner firms (as was demonstrated in Chapter 4) and will make it more likely that a firm in the searched network possesses the sought after capabilities or resources by the bridged firm. More specifically, establishing a non-local tie that increases the information diversity requires an extended network horizon.

When a bridged firm shifts its network position then this will have repercussions for the network position of the bridging firm. As the bridged firm develops alternative relationships that give access to similar capabilities or information compared with the bridging firm then this will weaken the bridging firm's network position. The bridged firm increases its discretion about resources and capabilities and diminishes its dependence on the bridging firm. This means that the bridging firm can reap fewer benefits and this will increase the probability that it will try to strengthen its bridging position. Therefore, we hypothesize:

> *Hypothesis 3*: A bridged firm with a high network horizon at *t* leads to a weakened bridging position of the focal firm at *t+1*.

While resource similarity and resource dependence may trigger the bridged firm to shift its network position, whether this is possible is partly dependent on its network horizon[43]. Firms experiencing either high levels of resource similarity or resource dependence but which have insufficient network horizon are still caught in their current network position. Having a more extended network horizon will make it more likely that the search for alternative partners is successful (as hypothesized in hypothesis 2). Accordingly, we finish with hypotheses four and five (the five hypotheses are illustrated in Figure 6-2):

Hypothesis 4: A larger network horizon strengthens the relationship between resource similarity and the weakening of the focal firm's bridging position.

Hypothesis 5: A larger network horizon strengthens the relationship between resource dependence and the weakening of the focal firm's bridging position.

[43] Many more factors trigger a firm to shift its network position. In particular, the switching costs (Chen & Forman, 2006; Zhu, Kraemer, Gurbaxani, & Xu, 2006) that a firm faces are an important factor whether a firm will search for a new supplier or stay with a current supplier. We test hypothesis 1 and 2 using field data from an interorganizational information system (IOS) (see Methodology Study 2: Field Study in this Chapter). Firms that are part of this IOS face two types of switching costs: 1) when a firm switches to a supplier who is also part of the IOS and 2) when a firm switches to another supplier that is not a member of the IOS. The first type of switching has probably lower switching costs compared with the second type. A firm that switches to a supplier who is also part of the IOS uses the same technical infrastructure thus investments in IT and training are minimal. However, a firm switching to a supplier who is not part of the IOS can incur significant costs. For example, the new supplier uses a different IOS that requires new IT investments and new training or the new supplier does not use an IOS at all which means that the efficiency gains of an IOS are foregone. The switching behavior that we observe is from firms that are part of the IOS and hence have low switching costs; our data set does not allow us to assess the costs of the second type of switching.

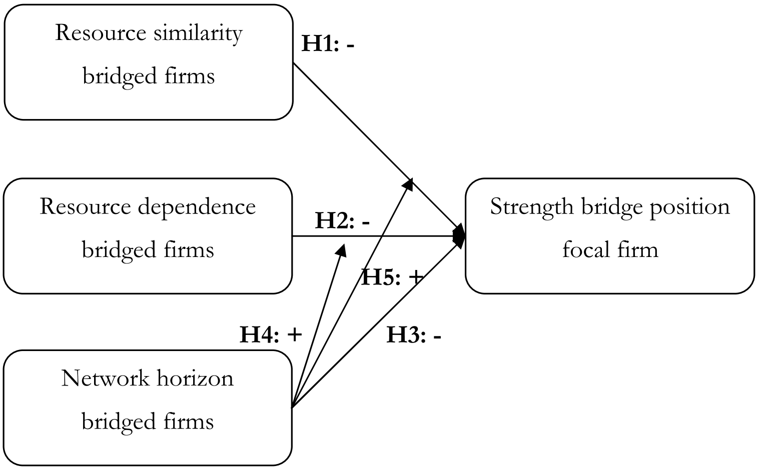

Figure 6-2 Summary hypotheses

6.2 Methodology Study 1 – Network Experiments

We will use two different research methods to test our hypotheses. First, we test the hypotheses using data that was acquired through network experiments. The design of the network experiments and the procedure by which we conducted the experiments has been discussed in detail in Chapter 3 and 4. Second, we use field data from the Dutch insurance industry to map the network of Dutch insurance firms and their brokers and use that setting to test the same set of hypotheses (except for hypotheses 2, 4, and 5 because data limitations do not permit us to test the network horizon based hypotheses in this empirical setting).

6.2.1 Participants and research design

We employed a random assigned within-subject design (Shadish et al., 2002). Three types of participants participated in the experiments. Managers from a large Dutch insurance firm and their insurance brokers, in total two hundred and ten participated. Students from different graduate courses participated, in total hundred twenty-six. Finally, we used a fixed student team (fifteen participants) that participated in multiple experiments. For the managers, insurance brokers, and the student team we used a scenario consisting of fifteen firms, for the graduate students we used a scenario of fourteen firms. The students participated individually in the experiments, the managers teamed up with an insurance broker. We will control for these differences by including dummy variables in the analysis. In order to replicate experiments, we conducted multiple experiments in a single session. Table 6-1 summarizes the descriptions of the participants

Participants	Number of sessions	Number of experiments	Number of participants	Years of industry experience (average /s.d.)	Scenario used
Managers & insurance brokers	7	12	210	15.49 /9.19	15 firms
Students	14	44	392	0.0 / 0.0	14 firms
Student team	8	22	15	0.0 / 0.0	15 firms
Total	**24**	**78**	**637**		

Table 6-1 Descriptives of the participants of the experiments

6.2.2 Experimental procedure

The participants were seated behind a computer after arrival in the computer lab where the experiments were conducted. Before the experiments started, an extensive one-and-half hour explanation of the network experiment was given. During this explanation, the participants practiced one round of the network experiment to teach them where to find relevant information, how to make decisions, and how to assess the impact of their decisions. The data obtained from this practice round was discarded. Participants were free to ask the instructors questions about the interface of the network experiment. After the practice round, control questions were distributed to verify whether the participants had a sufficient understanding of the network experiment to play it independently. Answers to these were checked and if necessary, some additional instruction was given to the participant before the experiments started. It was forbidden for participants to talk with each other and neither was there any help from the instructors during the second and third round, the rounds that were used for data collection. There was a debriefing session at the end of the experiments for educational purposes. The winner, the participant with the highest gross margin at the end of the experiments of a session was awarded with a gift coupon worth $25; the other participants received a fixed fee of $10.

6.2.3 Dependent variable

Bridging position partner firms. For each firm we calculate the strength of a firms' bridging position using Burt's (1992) network constraint measure. Constraint measures the extent to which a firm is dependent on its partner firms, when a firm is highly dependent it means it has little autonomy and therefore little control over the outcome of its activities. Therefore, network constraint is a measure of the control benefits of a structural hole. Constraint is a normalized measure with values ranging form zero to one. Firms without structural holes have a constraint of one while firms with many structural holes have a constraint value of zero. The definition of network constraint[44] is (Burt, 1992: 60):

Network constraint is: $\left(p_{ij} + \sum_q p_{iq} p_{qj}\right)^2, i \neq q \neq j.$

i = focal firm, j = alter 1 firm i, q = alter n of firm i; p_{ij} = investment of firm i's time and energy in the relationship with firm j; $p_{iq} p_{qj}$ = joint investment of time and energy of firm i and firm q in a relationship with firm j.

Next, we sum the total constraint among all partner firms of the focal firm and divide that by the number of partner firms. Finally, we multiply this measure by 100. This is the average constraint that the alter firms of a focal firm experience. Burt (2007) used this measure for his study on second-hand brokerage of investment bankers.

Network constraint is a measure that only takes into account the structure of the ego network. However, changes in the network position of a partner firm that do not affect the structure of the ego network of the focal firm are not considered by this measure. We will illustrate with an example (see Figure 6-3) that this can be inaccurate. The first illustration shows a bridging position for firm A. Firm A is relatively unconstrained (its network constraint measure is 1/3) because it has three partners who do not have any other relationships. The partner firms are dependent on firm A and are highly constrained (network constraint measure is for each partner firm 1.000). Suppose that at t+1 firm B establishes two new relationships: one with firm E and one with firm F. What are the implications for the bridging position of firm A? Burt's network constraint measure does not change because the two new firms do not belong to firm A's ego network. However, firm B has improved its network position. It has more bridging ties and it has become less dependent on firm A. The position of firm A has become weaker even though the network position of firm A has not deteriorated according to the network constraint measure. Therefore, we use the average network constraint of the partner firms to study when the bridging position of the focal firm weakens.

[44] See for a graphic illustration of the network constraint measure on page 101.

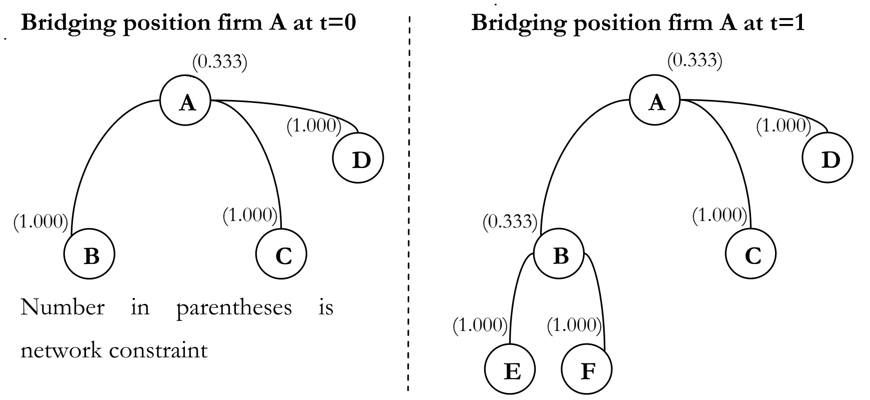

Figure 6-3 Illustration of network constraint for partner firms

The second dependent variable is effective size as was described op page 119. To calculate this measure for the strength of the bridging positions of the alter firms, we used the same procedure as described for the network constraint measure.

6.2.4 Independent variables

Network horizon. We operationalized network horizon as a continuous variable that counts how many firms the focal firm can 'see'. For firms with a limited network horizon we count the number of firms that can be reached within two steps, for firms that have an extended (or full) network horizon the number of firms the focal firm sees is equal to the network size (depending on the scenario 14 or 15 firms). This variable is updated after each decision point. This is consistent with the operationalization in Chapter 4. Next, we average the network horizon for all of the partner firms of the focal firm. This measure is used for hypotheses 2, 4 and 5.

Resource similarity. We base this measure on Chen's (1996) observation that resource similarity is an asymmetrical property. To measure the similarity we look at the capabilities a firm possesses. To measure the capability overlap of firm *i* with firm *j* we construct a matrix with on the rows and columns the firms that make up the network. Subsequently for row one (firm *i*) we count the number of capabilities that firm *i* has in common with firm *j* and divide that by the total number of capabilities firm *i* has. This procedure is repeated for each row, the result is a matrix that shows for each combination *(*firm *i,* firm *j)* the percentage of capabilities that firm *i* has in common with firm *j*. Finally, we sum the percentage of capabilities that firm *i* has in common with its partner firms and divide that by the total number of partner firms. This measure of resource similarity captures the average percentage of capabilities that are found in the network more than once. This measure is used for hypothesis 1.

Firm	***1***	***2***	***3***	***4***	***5***	**Sum**
1	0	0	0	0	0	0.0
2	0	0	0	0	0.5	0.5
3	0	0	0	1	0	1.0
4	0	0	0.5	0	0.5	1.0
5	0	0.5	0	0.5	0	1.0
Sum	0.0	0.5	0.5	1.5	1	Resource Similarity: (3.5+3.5)/25 = 0.28

Resource similarity is calculated by constructing a resource similarity matrix and for each pair of firms determining how many capabilities the firms have in common. This is summed and subsequently averaged for the ego network. The interpretation is as follows: two randomly picked firms have an expected resource similarity of 28%. 3.5 is the sum of the column and the sum of the row; 25 is the total number of observations.

Table 6-2 Example of the calculation of resource similarity

Resource dependence. A firm that is highly dependent when it outsources many of the capabilities it needs to deliver. Resource dependence is measured as the number of capabilities outsourced divided by the total number of capabilities that a firm should deliver. This is multiplied by 100 to make it a percentage. A value of 100 means that a firm does not possess any capabilities itself, but it has to outsource the capabilities to its network of suppliers to deliver the required capabilities. A value of 0 means that a firm possesses the required capabilities itself. This measure is used for hypothesis 2.

6.2.5 Control variables

We use an extensive set of control variables including focal firm characteristics, focal firm network position characteristics, alter firm characteristics, and alter firm network position characteristics to control for alternative explanations of why a firm does (not) change its network position.

Number of capabilities owned by the focal firm. This variable counts the number of capabilities the focal firm possesses. A firm that possesses many capabilities is less dependent on its suppliers and is therefore less likely to establish a new relationship.

Number of capabilities outsourced by the focal firm. This variable counts the number of capabilities the focal firm outsources. A firm that outsources many capabilities is more dependent on its suppliers and is therefore more likely to switch suppliers in case a new supplier offers a capability at a lower price.

Betweenness centrality of the focal firm. Betweenness centrality is a measure of how often a firm is located on the shortest path between two firms. A high value indicates that a firm is more central and has more influence in brokering information and resources between those two firms. Betweenness centrality is calculated as: $\sum_i \sum_j \frac{g_{ikj}}{g_{ij}}, i \neq j \neq k$ g_{ij} is the number of geodesic paths from *i* to *j*, g_{ikj} is the number of geodesic paths that pass along *k* and a geodesic path is the shortest path connecting two nodes in a network (Wasserman & Faust, 1994).

Average number of capabilities owned by the alter firms. This variable counts the average number of capabilities all the alter firms of the focal firm possess. A high number of capabilities owned by alter firm means that the focal firm is less inclined to establish a new relationship because it already has access to those capabilities.

Average number of capabilities outsourced by the alter firms. Counts the average number of capabilities all the alter firms of the focal firm outsources. A high number of capabilities that are being outsourced by alter firms means that the focal firm is less inclined to establish a new relationship because there is a maximum number of capabilities it can outsource.

Average betweenness centrality of alter firms. Alter firms that have a high betweenness centrality belong to the core of the network. These firms are more attractive to partner with, based on their on network position and hence make the focal firm less attractive. This variable is calculated by calculating the betweenness centrality for each partner firm and then it takes the average among all the partner firms.

Firms with zero relationships. When a firm has zero relationships then it is not possible to calculate the resource similarity because there are no partner firms to calculate resource similarity. Hence, for these firms resource similarity will be a missing value. These missing values have been replaced with a zero in the resource similarity variable and the variable firms with zero relationships were coded by one.

Furthermore, we add dummy variables for each firm, each type of strategy, a firm's initial network position, and the size of the network.

6.3 Analysis and Results – Network Experiments

The dependent variable is a continuous measure ranging from zero to one (before transforming the variable to a percentage). The observations are nested in different experiments, with different firms with multiple observations per firm leading to auto-correlation between observations. An observation of the network constraint of firm i at decision point 2 is dependent on the observation of the network constraint of firm i at decision point 1. Our data is nested and therefore observations are dependent, this is a violation of a key OLS assumption (Menard, 2002). To correct for this, we will use a longitudinal mixed method linear technique that allows for nesting of observations.

Table 6-3 summarizes the means, standard deviation, minimum, maximum, and the variance inflation factors (VIF) for the variables. Although most correlations are significant, the size of the correlations is generally small. Before continuing the analysis, we first assess to what extent multicollinearity affects our results. The variance inflation factors indicate to what extent multicollinearity is present between the variables. VIF values greater than 10 are considered problematic and are a strong indication of multicollinearity (Hair, Anderson, Tatham, & Black, 1998). The VIF values are well below the critical value of ten (see Table 6-3). Furthermore, we inspect how well the data is conditioned. Poor conditioning of the data is usually an indication of multicollinearity that results in imprecise variable estimates. The condition number for these data is 21.1279, which is well below the advised critical value of 30 (Belsley, 1991). Hence, we conclude that multicollinearity is not a significant issue.

We estimate six models (see Table 6-4) to investigate which partner firm factors contribute to the focal firm in changing its network position. We show the main effects separate of each other to investigate whether the hypothesized effects exist independently and jointly. The first model is a detailed baseline model using the control variables. The second model includes the main effect of resource similarity. The third model includes the main effect of network horizon. The fourth model includes the main effect of resource dependence. The fifth model adds the interaction effects between resource similarity and network horizon and resource dependence and network horizon. Finally, the sixth model adds includes all the main effects and interaction effects.

Each model is a significant improvement of the previous model and both the AIC and BIC information criteria indicate that model 6 is the most efficient model because AIC and BIC have the smallest value compared with the other models (Kennedy, 2003). Therefore, we will use model 6 to test our hypotheses.

The base line model is an extensive control model to account for alternative explanations such as focal firm characteristics and characteristics of the focal firm's network position. We have left out the control variables including the firm, strategy, and initial network position dummy to improve the readability of the table. We have reversed the network constraint variable to facilitate the comparison with effective size: high values indicate a strong bridging position while low values indicate a weak bridging position. Thus, we expect positive coefficients because a positive effect indicates that the bridging position becomes stronger. The second model adds the first main effect to test hypothesis 1. The first hypothesis stated that as partner firms become more similar in terms of their capabilities they would experience increased competition. To alleviate this competitive pressure those partners will establish ties outside the ego network of the focal firm to counter balance the power of the focal firm. We find the coefficient to be positive and significant and thus giving support for the first hypothesis.

The second hypothesis argued that the incentive to establish a new interfirm ties increases as partner firms become more dependent on the focal firm. Establishing new ties restructures their dependence but comes at the expense of the focal firm. We do find support for this hypothesis since the coefficient is positive and significant. The third hypothesis stated that as the network horizon of the partner firms increases, it is more likely that these partner firms find alternative firms that can substitute for the focal firm and thereby weakening the bridging position of the focal firm. The coefficient is positive and significant and thereby confirming our hypothesis.

Finally, we test the two interaction effects. The first interaction effect stated that when the network horizon of partner firms is extensive and these firms are facing a high level of resource similarity then these firms would have both the incentive and the means to shift their network position. Hence, we expect a positive sign for the coefficient. Counter to our hypothesis, we find a significant but negative sign. This rejects our hypothesis. An explanation for this finding can be that when a firm has an extensive network horizon and it still has similar capabilities compared with the other firms in the network then it is running out of possibilities. This can especially happen in the experiments since the network is rather small and the total number of unique capabilities is limited as well. This effect can particularly happen at the end of an experiment since the network structures tend to converge to an equilibrium where it is no longer possible to shift a firm's network position. The fifth hypothesis argued that there is a positive interaction effect between the average network horizon of partner firm and their average resource dependence. We do find support for this finding since the coefficient is positive as predicted and significant.

6.3.1 Robustness tests

We also conduct alternative methods of testing our hypotheses using three methods. First, we will conduct likelihood-ratio tests to check whether the joint effect of independent variables is statistically different from zero (Long & Freese, 2006). The final row in Table 6-4 shows the model improvement. Models 2, 3, 4 and 5 are compared with the baseline model and model 6 is compared with model 5. Each model is an improvement over its predecessor meaning that each model explains more variance compared with the previous model. This is emphasized by the decreasing values of both the AIC and BIC information criteria. Second, we conduct a Wald test. The Wald test tests whether a joint set of variables are different form zero. The Wald test is significant ($\chi^2_{(5)}$ = 834.17; p = 0.0000). (For the purpose of this test, we drop the interaction effect between network horizon of the partner firms and resource similarity because the expected sign of the coefficient was counter to our hypothesis). This gives further support for our findings that resource similarity, the average network horizon of partner firms and resource dependence determinants of the weakening of the bridging position of the focal firm.

Third, we rerun the models and use the average effective size of partner firms as our dependent variable. Table 6-5 presents the results of the same models as Table 6-4 but with a different dependent variable. Hypotheses 1, 3, and 5 are supported. Hypothesis 2 is not supported although it becomes significant in the model 6. However, the main effect without interaction effects is non-significant. We expect that model misspecification[45] is the cause that the coefficient becomes significant when we introduce the interaction effects. Hypothesis 5 is significant but the sign of the coefficient is counter to our prediction. This is consistent with the models based on the average partner network constraint. Concluding, our robustness tests give additional support for our hypotheses that resource similarity, resource dependence, and network horizon of partner firms weaken the bridging position of the focal firm.

[45] Model misspecification is a general term to cover a broad range of modeling errors including measurement errors, omitting independent variables (under-specified model), including extraneous independent variables (over-specified model), multicollinearity, and sampling constraints. In this particular case, however, it is more likely that the significance of the resource similarity variable is due to the inclusion of the interaction effect between resource similarity and network horizon that results in multicollinearity between resource similarity and the interaction effect of resource similarity and network horizon. Although the interaction variable is mean centered and the correlation between these two variables is .55 the number of observations is large enough to result in this kind error.

	Variables	Mean	S.D.	Min	Max	VIF	1	2	3	4	5	6
1	Average network constraint partner firms	37.5967	16.627	0	100	1.72	1					
2	Average effective size partner firms	3.2880	1.4675	0	9.0167	5.18	-0.1289	1				
3	Capabilities owned by firm i	1.5959	0.9230	0	6	1.53	0.2458	0.2974	1			
4	Capabilities outsourced by firm i	2.7576	3.5403	0	13	1.85	0.1744	0.0248	0.3273	1		
5	Average number of capabilities of by partner firms	1.6013	0.7060	0	5	1.86	0.2373	0.5773	0.2799	0.1267	1	
6	Betweenness centrality firm	5.0045	8.5291	0	77.0333	1.73	0.0718	0.1111	0.1102	0.4849	0.1018	1
7	Average betweenness centrality partner firms	6.6600	6.5225	0	64.1667	1.82	-0.1025	0.5001	0.1305	0.1218	0.2354	0.4390
8	Firms with no relationships	0.1967	0.3975	0	1	1.75	-0.2202	-0.4707	-0.5021	-0.2676	-0.3533	-0.1762
9	Average network horizon partner firms	12.3690	4.5720	0	16	2.95	0.2473	0.6630	0.3917	0.2026	0.5307	0.1800
10	Resource similarity partner firms	0.4848	0.2152	0	1	2.57	-0.0450	0.0352	-0.0673	-0.4498	-0.0026	-0.3393
11	Resource dependence partner firms	3.6450	2.3059	0	13	3.82	-0.1075	0.7621	0.2304	-0.0545	0.4900	0.1100
12	Network horizon partner firms * resource similarity•	0.0000	2.1964	-11.3333	10.65	2.12	-0.0233	-0.0106	-0.0021	-0.060	-0.0546	-0.1061
13	Network horizon partner firms * res. dep.•	0.0000	23.4584	-126.4261	123	2.44	-0.3364	0.4904	0.1041	0.0529	0.2010	0.1326
	Variables (continued)	**7**	**8**	**9**	**10**	**11**	**12**	**13**				
7	Average betweenness centrality partner firms	1										
8	Firms with no relationships	-0.2536	1									
9	Average network horizon partner firms	0.3026	-0.4796	1								
10	Resource similarity partner firms	-0.029	0.1251	-0.0425	1							
11	Resource dependence partner firms	0.5069	-0.3072	0.4220	0.1086	1						
12	Network horizon partner firms * resource similarity•	-0.0048	0.0672	0.1810	0.5575	0.0121	1					
13	Network horizon partner firms * res. dep.•	0.3848	-0.2005	0.2206	-0.1382	0.6348	0.0882	1				

Number of observations is 6687; correlations > |0.05| are significant at $p < 0.001$. • Interaction variables are mean centered. Res. dep. = resource dependence.

Table 6-3 Descriptive statistics and correlations

Dependent variable is average partner firms effective size	**Hypotheses and expected sign**	**Baseline model**	**Model 1 - Main effect resource similarity partner firms**	**Model 2 - Main effect network horizon partner firms**	**Model 3 - Main effect resource dependence partner firms**	**Model 4 - All main effects**	**Model 5 - Main and interaction effects**
Capabilities owned by firm i		0.698***	-0.188	0.651**	0.647**	-0.244	-0.223
		0.208	0.204	0.208	0.209	0.204	0.202
Capabilities outsourced by firm i		0.005	-0.015	0.055	-0.002	0.021	0.007
		0.08	0.077	0.081	0.08	0.078	0.077
Average number of capabilities owned by partner firms		2.346***	0.142	2.426***	1.934***	0.003	-0.091
		0.271	0.27	0.271	0.273	0.271	0.271
Betweenness centrality firm		-0.106***	-0.078***	-0.092***	-0.110***	-0.069***	-0.064***
		0.02	0.02	0.02	0.02	0.02	0.02
Average betweenness centrality partner firms		0.649***	0.359***	0.641***	0.616***	0.339***	0.324***
		0.026	0.027	0.026	0.026	0.027	0.027
Firms with no relationships		-3.411***	-2.586***	-3.511***	-2.982***	-2.405***	-2.123***
		0.472	0.449	0.473	0.473	0.451	0.452
Resource similarity partner firms	**H1 (+)**		2.266***			2.204***	1.714***
			0.081			0.081	0.126
Resource dependence partner firms	**H2 (+)**			3.800***		3.320***	7.525***
				0.764		0.727	1.203
Average network horizon partner firms	**H3 (+)**				0.627***	0.437***	0.521***
					0.061	0.057	0.069
Network horizon partner firms x resource similarity	**H4 (+)**						-0.409***

							0.099
Network horizon partner firms x resource dependence	**H5 (+)**						0.048***
							0.01
Control variables included		Yes	Yes	Yes	Yes	Yes	Yes
Constant		103.176***	102.397***	101.568***	102.770***	100.783***	98.607***
		0.919	0.851	0.969	0.871	0.86	0.975
N		6687	6687	6687	6687	6687	6687
AIC		49869.13	49138.72	49847.13	49773.39	49067.35	49041.02
BIC		50100.6	49377	50085.4	50011.67	49319.25	49306.53
Model improvement (Δ -2 log likelihood)			97.94***	24.01***	732.41***	807.78***	30.33***
Observation type							
Number of experiments	78						
Number of firms	1187						

Control variables include firm strategy, network position, manager or student, scenario (14 or 15 firms) and firm characteristics. * p<0.05, ** p<0.01, *** p<0.001

Table 6-4 Results of mixed multi-level time series regression analysis

Dependent variable is average partner firms effective size	**Hypotheses and expected sign**	**Baseline model**	**Model 1 - Main effect network horizon partner firms**	**Model 2 - Main effect resource similarity partner firms**	**Model 3 – Main effect resource dependence partner firms**	**Model 4 – All main effects**	**Model 5 - Main and interaction effects**
Capabilities owned by firm i		0.049**	-0.053***	0.047**	0.043**	-0.059***	-0.059***
		0.017	0.013	0.017	0.016	0.013	0.013
Capabilities outsourced by firm i		-0.005	-0.022***	-0.004	-0.008	-0.022***	-0.022***
		0.006	0.005	0.006	0.006	0.005	0.005
Average number of capabilities owned by partner firms		0.480***	0.194***	0.483***	0.436***	0.172***	0.162***
		0.019	0.016	0.019	0.019	0.016	0.016
Betweenness centrality firm		-0.020***	-0.014***	-0.020***	-0.020***	-0.014***	-0.014***
		0.002	0.001	0.002	0.002	0.001	0.001
Average betweenness centrality partner firms		0.078***	0.037***	0.077***	0.073***	0.035***	0.034***
		0.002	0.002	0.002	0.002	0.002	0.002
Firms with no relationships		-0.473***	-0.356***	-0.473***	-0.434***	-0.325***	-0.306***
		0.034	0.028	0.034	0.033	0.027	0.027
Resource similarity partner firms	**H1 (+)**		0.294***			0.284***	0.259***
			0.005			0.005	0.007
Resource dependence partner firms	**H2 (+)**			0.102		0.054	0.509***
				0.056		0.044	0.066
Average network horizon partner firms	**H3 (+)**				0.080***	0.059***	0.075***
					0.004	0.003	0.004

Network horizon partner firms x resource similarity	**H4 (+)**						-0.050***
							0.006
Network horizon partner firms x resource dependence	**H5 (+)**						0.003***
							0.001
Control variables included		Yes	Yes	Yes	Yes	Yes	Yes
Constant		0.462***	0.344***	0.423***	0.425***	0.291***	0.084
		0.063	0.052	0.066	0.059	0.051	0.055
N		6687	6687	6687	6687	6687	6687
AIC		14687.07	12074.76	14685.83	14264.37	11725.2	11638.13
BIC		14918.54	12313.04	14924.11	14502.65	11977.1	11903.63
Model improvement (Δ -2 log likelihood)			424.70***	3.24	2614.31***	2967.87***	91.08***
Observation type							
Number of experiments	78						
Number of firms	1187						

Control variables include firm strategy, network position, manager or student, scenario (14 or 15 firms) and firm characteristics. * p<0.05, ** p<0.01, *** p<0.001

Table 6-5 Results of mixed multi-level time series regression analysis

6.4 Methodology Study 2 – Field Study

So far, we used experiments to test our hypotheses. However, in order to increase the external validity of our findings we try to replicate our findings in an empirical setting. We collected archival data for the period 2002 – 2005 to construct the evolution of the Dutch insurance network to test our hypotheses regarding the weakening of bridging positions. In the Dutch insurance industry, there is an electronic network that facilitates the communication of transactions between insurance brokers and insurance firms called (in Dutch) the Assurantie Data Netwerk (ADN) or Insurance Data Network. We will use this data for our second method of this chapter. Two features of the network make this a useful data source: first, these are real transactions and therefore used as basis for monetary transactions. The ADN data consists of day-to-day transactions between insurance firms and brokers. Transactions include the prolongation of insurance policies and the applications for policies by new customers. Second, the Insurance Data Network covers approximately 10% of the total number of insurance brokers in the Netherlands.

6.4.1 Network definition

The network we will study consists of three different types of firms: insurance firms, authorized resellers, and insurance brokers. Insurance firms are responsible for marketing, product development, acceptation of customer, administration while the insurance broker is, mainly, responsible for sales and advice activities. The authorized resellers have integrated some activities that traditionally belong to the insurance firm like customer acceptation and administration. The network we study is based on buyer – supplier relationships, hence an insurance broker has to sell insurance products from one or more insurance companies. This applies to the authorized resellers as well. While we collected transaction data between insurance broker and insurance firm on a daily basis, we aggregated this data to a yearly basis in order to stabilize our results. We did not use a moving window approach because the month-to-month variance was too limited to be meaningful and is computationally infeasible; hence, we have between one and four observation points for each insurance broker (2002, 2003, 2004, and 2005). The number of observations differs per year because brokers can exit the Insurance Data Network during the window of observation.

6.4.2 Selection bias

It is possible that insurance brokers that have joined the Insurance Data Network differ on key firm characteristics compared with insurance brokers that did not join the Insurance Data Network. For example, firms belonging to the Insurance Data Network are possibly significantly larger in terms of firm size compared with ordinary insurance brokers (information was obtained from the REACH database). This can potentially bias the results. Therefore, we conduct a t-test and assume different variances for the two samples (firms from the REACH database and firm from the ADN network). We tested whether the average number of employees of the firms in the Insurance Data Network is significantly different from the average number of employees of the firms that do not participate with the Insurance Data Network. The t-test indicates that the firms in Insurance Data Network are significantly larger (p = 0.0000) in terms of average number of employees than ordinary insurance brokers. The implication of this selection bias is that the firms in our sample are more likely to shift their network position because larger firms have more resources available and have therefore greater discretion in the partnering actions they take. Smaller insurance broker firms may not be able to establish or terminate relationships with the same flexibility as larger insurance broker firms.

6.4.3 Dependent variable

Bridging position partner firms. We use the same dependent variable as in our first study of this chapter. Thus, we calculate effective size for each firm (see page 97) and network constraint for each firm (see page 98). Next, we sum the network constraint for a focal firm's alter firms and we average those values[46].

6.4.4 Independent variables

Resource dependence. Resource dependence is an asymmetric construct (Casciaro & Piskorski, 2005); therefore, we measure the dependence of a broker on the insurance firms and the dependence of insurance firms on brokers independently. We calculate the dependence of a broker on its insurance firms by taking the variance of the net value of insurance products sold to consumers. A high variance is an indication that an insurance broker is selling insurance products from one insurance firm and is therefore dependent on that particular insurance firm. A low variance indicates that the broker sells insurance products from different insurance firms and is less dependent on any one firm in particular. This variable has a minimum value of zero and is unbounded.

An insurance firm is dependent on an insurance broker to the extent the broker covers exclusively a geographic area. An insurance firm that has a geographic area covered by one broker is highly dependent on that broker compared with an insurance firm that has multiple brokers covering the same geographic area. This variable ranges from 0 (no dependence) to 100 (highly dependent).

Resource similarity. We measure resource similarity using the following procedure. We have collected four digits (out of the six) of the zip codes of each customer for each broker in our dataset. These zip codes have been transformed into longitude and latitude coordinates. Converting zip codes to longitude and latitude coordinates has previously been done by Casciaro and Piskorski (2005). Next, using the convex hull algorithm (Weisstein, 2006), we calculate the geographic area a broker covers. The convex hull algorithm calculates the coordinates of a polygon that includes a set of points. In our case, we have a set of customers with their zip codes that constitute a set of points. The convex hull algorithm calculates the polygon that includes all the customers. We repeat this for each broker in the dataset. Then, we identify the competitors of the focal broker by looking at which brokers are positioned in the geographic area of the focal broker. The result of this process is illustrated in Figure 6-4.

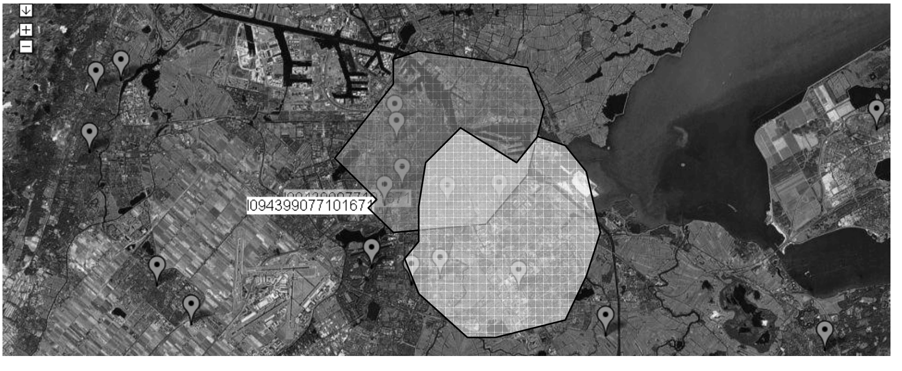

Figure 6-4 Illustrative example of calculating resource similarity variable[47]

[46] The data collection for the dependent, independent and control variables is described in Section 3.6.

[47] We built a Google Maps application to visualize the Dutch insurance industry network. The application is available at dep01-server02.fbk.eur.nl:8100/adn/.

The overlap determines who is competing with whom. Having established the competitors of an insurance broker, then we look at the products each broker offers. The percentage of overlap in products is resource similarity. For example, if broker A is offering car and travel policies and broker B is offering only travel policies then broker A has a resource similarity of 50% (1 product in common out of 2 products offered) while broker B has a resource similarity of 100% (1 product in common out of 1 product offered). Resource similarity ranges from 0% to 100%. This measure is consistent with the resource similarity measure we used in the first study of this chapter. Furthermore, this measure is consistent with Chen's (1996) observation that resource similarity is an asymmetrical property between two or more firms.

6.4.5 Control variables

The number of ties an insurance broker will maintain also depends on a number of industry and firm specific factors. Hence, we will construct an extensive baseline model based on the following industry and firm specific control variables to control for alternative explanations of why a bridging position weakens.

Number of property insurance firms. This variable counts the number of property insurance firms active in the Netherlands. When more insurance firms are active then it becomes more likely that insurance brokers will maintain more relationships with different insurance firms.

Number of SER A / SER B / SER GA licenses. These three variables count the total number of insurance brokers with either an A, B or GA registration. An A license indicates that the advisers of the insurance broker are better qualified and trained in selling insurance products compared with a B license. A GA license indicates that a broker is authorized to accept new customers independently from the insurance firm and to resell insurance products under their own brand. The entry of new brokers might increase the competition between them and hence negatively influence the number of ties a broker maintains because an insurance firm can choose from more brokers.

Total industry policies sold. This variable counts the total number of insurance policies being sold through insurance brokers and direct writers. This variable is an indication of how well the industry is doing in a particular year.

Furthermore, we use the following firm characteristics to control for alternative explanations of the bridging position of a broker.

Number of employees. Counts the number of employees (full time equivalent) working at a broker. This is a measure of firm size; larger brokers may have more resources at their disposal to shift their network position.

Broker professional memberships. These are three dummy variables that indicate whether an insurance broker is a member of one of three professional industry organizations that act as independent quality auditor. NVA and stands for Dutch Association for Insurance Brokers and Financial Service Firms (Nederlandse Vereniging van Assurantieadviseurs en Financiële Dienstverleners). One of the activities of the NVA is to participate in different committees to enhance the interests of its members. The NVGA stands for Dutch Association of Authorized Resellers (Nederlandse Vereniging van Gevolmachtigde Assurantiebedrijven). The NVGA acts as independent quality auditor for authorized resellers that can independently of the insurance firm accept new customers. The NBVA stands for Dutch Association for Insurance Brokers (Nederlandse Bond van Assurantiebemiddelaars) and is an association for independent insurance brokers with 900 members.

Broker qualification. This variable indicates whether a broker has an SER A, SER B, or SER GA license.

Captive. This variable measures the ownership of a broker by an insurance firm. Captivity is an indicator of restricted autonomy of the broker and is therefore less likely to establish new ties.

Market area covered by broker. This variable measures the market area (in km^2) that a broker services. This variable is an indicator of how powerful a broker is vis-à-vis the insurance firms.

Number of customers. The number of customers a broker services is an indicator of firm size and possibly power vis-à-vis insurance firms. Brokers with more customers are more likely to unilaterally shift their network position because of their reduced dependence.

Firm with one relationship. A broker with one relationship is highly dependent upon the insurance firm. Most of these firms are captured by the captive variable, however this variable is an extra check to control for highly dependent firms.

Year dummy. Finally, we included year dummies to account for year specific events.

6.5 Analysis and Results – Field Study

The collected data are panel data: we have multiple observations per firm, hence we need time-series regression analysis to analyze the data. The data of the field study are not nested in contrast to the first study of this chapter. To prevent simultaneity problems we lag the independent variables one year (Kennedy, 2003). Thus, 2001 observations are used to predict the strength or weakness of a firm's bridging position in 2002.

Table 6-6 shows the means, standard deviation, range, variance inflation factors (VIF), and the correlations. Before continuing the analysis, we first assess to what extent multicollinearity affects our results. The variance inflation factors indicate to what extent multicollinearity is present between the variables. VIF sizes greater than 10 are considered problematic and are a strong indication of multicollinearity (Hair et al., 1998). The VIF values are well below the critical value of ten. Furthermore, we calculate the conditioning index number (Belsley, 1991), the conditioning number is 13.9401, which is well below the critical value of 30. Hence, we conclude that multicollinearity does not materially affect our results.

We estimate four models (see Table 6-7) to investigate which partner firm factors contribute to the focal firm in changing its network position. We show the main effects separate of each other to investigate whether the hypothesized effects exist independently and jointly. The first model is a detailed baseline model using the control variables. The second model includes the main effect of resource similarity. The third model includes the main effect of resource dependence. Finally, the fourth model includes both main effects.

Each model is a significant improvement of the previous model and both the AIC and BIC information criteria indicate that model 4 is the most efficient model because AIC and BIC have the smallest value compared with the other models (Kennedy, 2003). Therefore, we will use model 4 to test our hypotheses.

The base line model is an extensive control model to account for alternative explanations such as focal firm characteristics and characteristics of the focal firms' network position. We reverse coded network constraint: high values indicate a strong bridging position while low values indicate a weak bridging position. Thus, we expect positive coefficients because a positive effect indicates that the bridging position becomes stronger. The second model adds the first main effect to test hypothesis 1. The first hypothesis stated that as partner firms become more similar in terms of their capabilities they would experience increased competition. To alleviate this competitive pressure those partners will establish ties outside the ego network of the focal firm to counter balance the power of the focal firm. We find the coefficient to be positive and significant and thus giving support for the first hypothesis. The second hypothesis argued that the incentive to establish a new interfirm tie increases as partner firms become more dependent on the focal firm. Establishing new ties restructures their dependence but comes at the expense of the focal firm. We do not find support for this hypothesis since the coefficient is negative and significant. This suggests that dependent firms, either voluntarily or coerced, strengthen their relationship with the bridging party by abandoning less important interfirm relationships. This is in contrast with the findings from the network experiments, which suggested that dependent firms would search for alternative partner firms.

6.5.1 Robustness tests

Finally, we also conduct alternative methods of testing our hypotheses using three methods comparable with the robustness tests of the network experiments. First, we will conduct likelihood-ratio tests to check whether the joint effect of independent variables is statistically different from zero (Long & Freese, 2006). The final row in Table 6-7 shows the model improvement. Models 2, 3, and 4 are compared with the baseline model. Each model is an improvement over its predecessor meaning that each model explains more variance compared with the previous model. This is emphasized by the decreasing values of the AIC, the BIC information criterion is a bit more ambiguous, and according to the BIC is model 3 the most parsimonious. Second, we conduct a Wald test. The Wald test confirms whether a joint set of variables are different form zero. The Wald test is significant ($\chi^2_{(5)} = 86.36$; $p = 0.0000$). This gives further support for our findings that resource similarity and resource dependence are determinants of the weakening of the bridging position of the focal firm. Third, we rerun the models and use the average effective size of partner firms as our dependent variable. Table 6-8 resents the results of the same models as Table 6-7 but with the average effective size of partner firms as the dependent variable. Hypotheses 1 is not supported but hypothesis 2 is, which is an exact replication of the previous findings. Thus, in the field study we find strong support for our prediction that resource similarity leads to a weakening of a bridging position while resource dependence leads to the strengthening of a bridging position. The last finding is counter to our predictions but it could suggest that the dependence is managed not through unilateral restructuring (i.e. the dependent firm searches for a new partner firm) but that a dependent firm is more likely to adopt a bilateral strategy (Pfeffer & Salancik, 1978) to manage the dependence. In this case, the dependence is managed by the dependent firm strengthening its relationship with the bridging firm. A possible suggestion for this inconsistent finding is that we used two different operationalizations for resource dependence. In the network experiments, we used the number of capabilities outsourced while in the field study we used the variance of procured insurance policies.

	Variables	Mean	S.D.	Min	Max	1	2	3	4	5	6	7
1	Average network constraint partner firms	0.0115	0.0181	0.001	0.5	1						
2	Average effective size partner firms	714.2075	263.32	2	1392.3051	-0.373	1					
3	Number of insurance brokers with SER A license	3681.6	176.1264	3484	3958	-0.0432	-0.017	1				
4	Number of policies sold (industry level)	3.63E+07	3.43E+06	3.30E+07	4.07E+07	0.0294	-0.0543	-0.8333	1			
5	Number of property insurance firms	836.4	72.7339	786	981	-0.0265	-0.4313	0.778	-0.3779	1		
6	Brokers is NVA member	0.1432	0.3503	0	1	-0.0471	0.121	0.1213	-0.1299	0.0492	1	
7	Broker is NVGA member	0.0165	0.1275	0	1	0.0339	-0.0232	0.0299	-0.0371	0.0052	0.1655	1
8	Broker is NBVA member	0.1264	0.3324	0	1	0.0304	0.1324	0.0962	-0.1137	0.0255	-0.1543	-0.0253
9	Number of employees	8.0907	25.5659	0	700	0.0247	-0.0559	-0.0107	0.0061	-0.0129	0.1295	0.1058
10	Number of products offered	28.1158	9.0868	0	145	0.0373	0.1008	-0.2515	0.1525	-0.2716	0.146	0.1035
11	Broker has SER A license	0.3299	0.4702	0	1	0.0226	-0.0207	0	0	0	0.2434	0.1605
12	Broker has SER B license	0.7746	0.4179	0	1	-0.0727	0.061	0	0	0	-0.2154	-0.1925
13	Broker is captive	2.7819	15.7525	0	100	-0.0369	-0.0017	0	0	0	0.1219	0.0897
14	Market area covered by broker	212.6452	198.6794	0	1530.9955	0.0484	-0.0009	-0.311	0.2378	-0.3102	0.1585	0.1033
15	Number of customers	3928.7963	1.19E+04	0	4.58E+05	0.1825	-0.1469	-0.1022	0.0591	-0.1114	0.0473	0.0955
16	Firm with one relationship	0.1503	0.3573	0	1	0.0005	-0.142	0.0214	-0.003	0.0348	-0.1219	-0.0257
17	Resource dependence (log)	21.6956	3.9529	0	41.7613	0.0519	0.1524	-0.2048	0.0987	-0.2428	0.1287	0.0488
18	Resource similarity	0.3264	0.163	0	0.5315	-0.0571	0.2276	-0.6621	0.3134	-0.8538	0.0284	0.0327

	Variables (continued)	8	9	10	11	12	13	14	15	16	17	18
8	Broker is NBVA member	1										
9	Number of employees	-0.0534	1									
10	Number of products offered	0.0543	0.0934	1								
11	Broker has SER A license	-0.0642	0.1543	0.1267	1							
12	Broker has SER B license	0.0589	-0.1304	-0.0827	-0.7095	1						
13	Broker is captive	-0.0583	0.1349	0.0613	0.1644	-0.0987	1					
14	Market area covered by broker	-0.0727	0.222	0.4613	0.2139	-0.1653	0.156	1				
15	Number of customers	0.0011	0.2838	0.258	0.0718	-0.0945	0.0985	0.357	1			
16	Firm with one relationship	-0.0919	-0.0155	-0.1204	-0.0501	0.0249	-0.0186	-0.0204	-0.1203	1		
17	Resource dependence (log)	0.0105	0.1299	0.6114	0.1055	-0.0706	0.0844	0.3927	0.2667	-0.1342	1	
18	Resource similarity	0.0146	0.0188	0.6537	0.0326	-0.0147	-0.0018	0.4085	0.1487	-0.0218	0.5017	1

Number of observations is 6324 and number of firms is 2025. Correlations > |0.0299| are significant at p <0.001.

Table 6-6 Descriptive statistics and correlations

Dependent variable is average network constraint partner firms (reverse coded and multiplied by 100)	**Hypotheses and expected sign**	**Baseline model**	**Model 1 - Main effect resource dependence partner firms**	**Model 2 - Main effect resource similarity partner firms**	**Model 3 - All main effects**
Number of insurance brokers with SER A license		0.0001	0.0001	0.0007	0.0011*
		0.0005	0.0005	0.0005	0.0005
Number of policies sold (industry level)		0	0	0	0.0000*
		0	0	0	0
Number of property insurance firms		0.0028	0.0026	0.0089*	0.005
		0.0036	0.0039	0.0036	0.0039
Broker is NVA member		0.1323*	0.1327*	0.1046	0.113
		0.0645	0.0646	0.0641	0.0641
Broker is NVGA member		0.1035	0.1035	0.1121	0.1115
		0.1708	0.1708	0.1696	0.1695
Broker is NBVA member		0.0063	0.0062	-0.0026	-0.0068
		0.0656	0.0657	0.0652	0.0651
Number of employees		0.0006	0.0006	0.0012	0.0014
		0.0009	0.0009	0.0009	0.0009
Number of products offered		-0.0153***	-0.0150**	-0.0890***	-0.0899***
		0.0041	0.0046	0.0093	0.0093
Broker has SER A license		0.0343	0.0345	0.0648	0.0721
		0.0963	0.0963	0.0944	0.0943
Broker has SER B license		0.1193	0.1195	0.0891	0.0919
		0.108	0.108	0.1059	0.1057
Broker is captive		0.0042*	0.0043*	0.0049**	0.0051**

		0.0019	0.0019	0.0019	0.0019
Market area covered by broker		0.0001	0.0001	0.0001	0.0002
		0.0001	0.0001	0.0001	0.0001
Number of customers		-0.0000**	-0.0000**	0	0
		0	0	0	0
Firm with one relationship		-0.0562	-0.0562	-0.0566	-0.0566
		0.1074	0.1074	0.1068	0.1067
Resource dependence (log)	**H1: (+)**		-0.0015		-0.0354**
			0.0122		0.0126
Resource similarity	**H2: (+)**			7.3805***	8.0940***
				0.8341	0.871
Constant		96.8929***	96.9956***	87.7631***	89.2857***
		1.5512	1.7577	1.8613	1.9378
Random intercept of level-2		1.1910***	1.1910***	1.1589***	1.1570***
Constant		0.026	0.026	0.0257	0.0257
Within-firm standard deviation					
Constant		1.1263***	1.1263***	1.1269***	1.1266***
		0.0123	0.0123	0.0123	0.0123
N		6324	6324	6324	6324
AIC		22425.37	22427.36	22350.19	22344.31
BIC		22540.16	22548.89	22471.73	22472.6
Model improvement			0.02	77.18***	85.06***

* p<0.05, ** p<0.01, *** p<0.00; number of firms: 2025; year dummy variables are included in analysis but excluded from reported results.

Table 6-7 Results of random effects time series regression analysis

Dependent variable is average effective size partner firms	Hypotheses and expected sign	Baseline model	Model 1 - Main effect resource dependence partner firms	Model 2 - Main effect resource similarity partner firms	Model 3 - All main effects
Number of insurance brokers with SER A license		2.5186***	2.5219***	2.5793***	2.6236***
		0.0537	0.0554	0.0541	0.0566
Number of policies sold (industry level)		0.0001***	0.0001***	0.0001***	0.0001***
		0	0	0	0
Number of property insurance firms		-28.3404***	-28.3829***	-27.7177***	-28.1466***
		0.3871	0.4259	0.3935	0.4252
Broker is NVA member		9.4403	9.5481	7.1102	8.1195
		7.2578	7.2718	7.2329	7.2402
Broker is NVGA member		-21.7207	-21.6601	-22.7443	-22.1704
		19.1454	19.1472	19.067	19.0622
Broker is NBVA member		13.3565	13.327	12.9959	12.6188
		7.4225	7.4236	7.3899	7.3882
Number of employees		-0.06	-0.0591	-0.0045	0.0123
		0.0979	0.098	0.0977	0.0979
Number of products offered		-0.9921*	-0.9286	-9.0885***	-9.1499***
		0.4831	0.5513	1.1096	1.109
Broker has SER A license		5.5303	5.5731	9.3858	10.2519
		13.2647	13.265	13.0882	13.0609
Broker has SER B license		22.084	22.1453	18.7917	19.1724
		14.8714	14.8726	14.6698	14.6354
Broker is captive		-0.0238	-0.0223	0.0628	0.0884

		0.2598	0.2599	0.2565	0.2561
Market area covered by broker		0.0254	0.0257	0.0251	0.0288
		0.0151	0.0151	0.015	0.0151
Number of customers		-0.0032***	-0.0032***	-0.0021***	-0.0019***
		0.0004	0.0004	0.0004	0.0004
Firm with one relationship		16.0549	16.0359	15.4101	15.1329
		11.8517	11.852	11.8081	11.8049
Resource dependence (log)	**H1: (+)**		-0.3432		-3.9602**
			1.4356		1.4875
Resource similarity	**H2: (+)**			804.5005***	883.3129***
				99.3948	103.6309
Constant		1.04e+04***	1.05e+04***	9471.7419***	9638.1825***
		166.0695	191.0962	204.0745	213.402
Random intercept of level-2		175.5038***	175.4888***	172.6741***	172.1805***
Constant		3.2937	3.294	3.2637	3.26
Within-firm standard deviation					
Constant		116.1052***	116.1083***	115.9938***	116.0289***
		1.2608	1.2609	1.2609	1.2617
N		6324	6324	6324	6324
AIC		82222.11	82224.05	82159.1	82154.02
BIC		82336.9	82345.59	82280.64	82282.31
Model improvement			0.06	65.01***	72.09****

* p<0.05, ** p<0.01, *** p<0.00; number of firms: 2025

Table 6-8 Results of random effects time series regression analysis

6.6 Conclusion

Salancik (1995) argued that the field of network research should move beyond questions about the effects of network positions and raise questions that focus on why particular positions exist or do not exist in the first place. Salancik (1995: 349) phrased it as follows: "a more telling analysis might explain why the hole exists or why it was not filled before." This chapter addressed the issue under what circumstances the bridging position of the focal firm weakens. In order to do so, we moved our focus away from the focal partner and looked at the partnering behavior of its alter firms. Next, we identified two different situations: 1) partner firms are homogenous which leads to resource similarity among the partner firms and 2) partner firms are heterogeneous which leads to dependence between the partner and bridging firm (Reagans & Zuckerman, 2006). Partner firms of a bridging firm who shift their network position undermine the strength of the focal firm's bridging position because they become less dependent on the bridging firm. We argued that resource dependence and resource similarity are two possible explanations why the alter firms will partner with other firms. We used two research methods to investigate which partner firm characteristics affect the bridging position. First, we employed network experiments. The network experiments give robust support to our predictions. Partner firms with similar resources compared to other partner firms of the bridging party or partner firms that are dependent on the bridging firm are very likely to shift their network position by establishing new interfirm ties. The effect of these new interfirm ties is that both the control and information benefits of the bridging party weaken. The control benefits weaken because the partner firms become less dependent and have alternatives to the bridging firm. Furthermore, the partner firms that establishes new ties gets access to new parts of the network and thereby creating information benefits themselves. Both effects weaken the bridging position of the focal firm. Furthermore, we argued that if partner firms have a more extended network horizon then they will be more aware of alternative network partners and can more easily escape from their disadvantaged position. We also found support for this prediction. Finally, we investigated whether there are interaction effects between resource dependence and network horizon of the partner firms and resource similarity and network horizon of the partner firms. We did find support for the interaction effect between resource dependence and network horizon of the partner firms.

Second, we conducted a field study in the Dutch insurance industry to increase the generalizability of our first findings. This study replicated the resource similarity finding from the network experiments and thereby increasing the robustness of the previous finding. However, the field study did not support our second hypothesis. A possible explanation is that although the bridged firm has the incentive to shift its network position because of its high dependence, it cannot shift its position because the insurance firms are more powerful and broker firms are afraid that establishing new relationships with another insurance firm they may jeopardize their current relationship.

Our three predictions (resource dependence, resource similarity, and network horizon) can be categorized according to the basic motive behind the change of a firm's network position. Firms changing their network position because of resource dependence or resource similarity do so because they perceive both factors as threats to the performance of their firm. A highly dependent firm has less discretion about the actions it can take. This loss of control translates in more uncertainty and accepting worse exchange conditions. Firms changing their network position because of resource similarity do so because they experience increased competition. Resource similarity weakens the bargaining position and increased pressure on prices. However, firms changing their network position because they spot alternative partners in the network do so because they perceive an opportunity to improve their network position. Threat and opportunity categorization is consistent with previous work on how organizational decision-makers scan and filter their environment (Hambrick, 1982), interpret (Baum et al., 2003; Porac et al., 1995) and categorize the obtained information (Jackson & Dutton, 1988).

Our findings suggest that the two most valuable types of bridging positions carry their own seeds of demise. The first type of a bridging position is the situation in which the bridged firms are homogenous (Reagans & Zuckerman, 2006). This situation leads to high levels of resource similarity and thereby creating the incentive for the bridged firms to shift their network position. The second type of a bridging position is the situation in which the bridged firms are heterogeneous (Reagans & Zuckerman, 2006). This situation means that a bridged firm is highly dependent on the bridging firm and this creates the incentive for the bridged firm to start partnering with other firms in the network.

Although we tried to make our results as robust as possible using a multi-method research design and different operationalizations of the dependent variable, there remains one important limitation. This limitation is that we did not measure the partnering actions of firms directly (for example using a binary variable to code whether a firm has established or terminated a tie) but we used the indirect measure of network constraint. This raises the possibility that the partnering behavior of the bridged firms confounds with the partnering behavior of its partner firms (thus the partners of the partners of the focal firm). A shift in the network position of the partner firms may be attributable to the partnering actions of the partner firm itself or its partner firms. This possibly obscures the causality: did the partner firm shift its network position in response to the focal firm? Or did the network position of the partner firm shift due to partnering actions by its partners? This constitutes an infinite regress problem; future research should consider the firm that initiates the tie to observe more directly changes in network positions to address this problem.

Finally, we think that by incorporating the partnering actions of both the bridging and the bridged firms we gain a more comprehensive understanding of the dynamics of the bridging network position. Pollock, Porac and Wade noted that "not all structural holes are equivalent and equally attractive" (2004:51) and this research suggests that the two most valuable types of bridging positions seem to be the ones that will not last long.

7 Conclusions

This research was aimed at increasing our understanding of the dynamics of network positions and in particular, the dynamics of bridging positions. A brief summary including the main findings of the three empirical chapters is given which we will subsequently synthesize in a model of network position dynamics. Next, we discuss the generalizability and limitations of the results and in particular the managerial relevance of these findings. Finally, we look at some directions for future research.

7.1 Summary of Main Findings

This study started with the overall research question of why a firm's network position changes. In order to answer this question, we narrowed down the scope of the research and decided to focus exclusively on the bridging position because it is an important source of value creation (Burt, 2000) and is the object of strategic action by firms (Baum et al., 2003; Rowley & Baum, 2002; Rowley & Baum, 2004). As Salancik (1995: 349) noted "Why does a structural hole exist? Why was it not filled before?" This dissertation develops a model of the dynamics of network positions based on firm, partner firm and network level factors. Our focus on the bridging position led to three detailed research questions, each covering a particular aspect of the life cycle of a bridging position. The first detailed research question: why does a bridging position strengthen? is answered in Chapter 4. Next, we investigate why do some bridging positions last longer than other bridging positions? when firms compete for bridging positions and thereby answering the second detailed research question in Chapter 5. Finally, we address the third detailed research question: why do bridging positions weaken? in Chapter 6 which looked at the influence of bridged firm's partnering actions on the bridging position of the focal firm.

7.1.1 Findings Chapter 4

The first empirical chapter answers the first detailed research question: why do bridging positions strengthen? Chapter 4 argues that firms need to have information about the network structure (i.e. network horizon) to strengthen their bridging position. Using both network experiments and computational modeling, we concluded Chapter 4 with four findings:

1. Firms with a more extended network horizon will span more structural holes compared to firms with a more limited network horizon.
2. Having a more extended network horizon in itself is a required but insufficient condition to span more structural holes. Our findings suggested that the participants from the fixed student team were better in strengthening their bridging positions compared with participants who participated only once because they learned to assess the benefits of a bridging position in the context of the network experiments. The implication of this finding is that organizational decision-makers have to understand the value of a particular network position in order to make the proper decisions to arrive at such position (we will discuss this in section about managerial relevance as well).
3. The network horizon heterogeneity is a determinant of how long a firm can benefit from a particular network position. Greater heterogeneity means that a firm with a more extended network horizon will benefit longer from its position because other firms are not able to make partnering decisions that threaten the network position of the focal firm.
4. For a given network, there are diminishing returns for the network horizon. After a certain information threshold, there is no utility for a firm to collect even more information about the network because it does not lead to a more favorable network position.

These findings suggest that the network horizon of a firm is an important and robust factor for a firm to strengthen its bridging position. How to collect information about the network structure in an empirical setting will be addressed in the Future Research section.

7.1.2 Findings Chapter 5

Chapter 5 answers the second detailed research question: why do some bridging positions last longer than other bridging positions? Chapter 5 presents evidence, using a computational model, that the network horizon heterogeneity is an important determinant for the intensity of the competition for bridging positions. Network horizon heterogeneity is a network level construct, thus we incorporate how the partnering behavior of other firms in the network affect the bridging position of the focal firm. More specifically, we concluded Chapter 5 with three findings:

1. The sustainability of a bridging position increases as the network horizon heterogeneity increases. Thus, network horizon heterogeneity is a positive moderator of the sustainability of a bridging position for a firm with an extended network horizon.
2. In addition to the fact that firms with an extended network horizon span more structural holes (consistent with Chapter 4) we find that firms with an extended network horizon are able to profit from these bridging positions are more sustainable because rival firms with a limited network horizon do not detect these valuable brokerage opportunities.
3. The network horizon of partner firms has a positive influence on the sustainability of the bridging position of the focal firm.

7.1.3 Findings Chapter 6

Chapter 6 answers detailed research question three: why do bridging positions weaken? We moved the focus from the focal firm to its partner firms, i.e. the bridged firms, and investigated how their partnering decisions impact the focal firm's bridging position. The first study of Chapter 6, using network experiments, presents evidence that bridged firms will improve their network position because of two basic motives: 1) these bridged firms detect opportunities in the network to improve their current network position and 2) these bridged firms experience either high levels of competition or dependence and then commence partnering actions to alleviate this pressure. The four findings of the first study of Chapter 6 are:

1. Bridged firms with an extensive network horizon improve their network position which weakens the bridging position of the focal firm.
2. Bridged firms that are dependent on the focal firm will restructure their dependence by establishing new interfirm relationships. These new relationships weaken the bridging position of the focal firm.
3. Bridged firms that have similar capabilities compared to other partner firms of the focal firm will shift their network position to reduce the similarity. These partnering actions weaken the bridging position of the focal firm.

4. Finally, bridged firms with high levels of dependence and an extended network horizon contribute even more to the weakening of the bridging position of the focal firm.

The second study of Chapter 6 focused in particular on resource dependence and resource similarity in the context of the Dutch insurance industry. The two findings of the second study are:

1. Bridged firms with similar capabilities will reduce the level of competitive intensity by shifting their network position and thereby weaken the bridging position of the focal firm.
2. Bridged firms that are dependent on the bridging firm increase their dependence by abandoning less important relationships and thus strengthen the bridging position.

7.2 Synthesis of the Findings

Figure 7-1[48] integrates the findings of the three empirical studies into a single model of the dynamics of a bridging position. Each study addressed factors at a different level: Chapter 4 focused primarily on the firm (and to some extent on the network level), Chapter 5 focused on the network level, and Chapter 6 focused on the ego network of the focal firm. Thus, the findings of the previous section suggest that although the focal firm can actively strengthen its bridging position by the partnering decisions it takes, the strength also depends on the partnering decisions of its partners (local network effects) and the partnering decisions of other network firms (global network effects).

This suggests that a firm should pay attention to both local and global changes in the network to be able to maintain its current network position. At the start of this dissertation, we raised the following overall research question:

"Why does the network position of a firm change?
Which firm, partner firm and network factors accelerate or slow down this change process?"

---

[48] In Chapter 2, we illustrated how technology and specialization are drivers of the increased use of interfirm networks. We argued that interfirm networks would be more often used as technology and specialization progress. This figure illustrates, given the technology and specialization developments of Figure 2-1, how within such an interfirm network the bridging position is affected by firm, partner firm and network level effects.

We can now conclude that the answers to these questions are that a network position changes because a firm either identifies opportunities to strengthen its network position due to its network horizon or that a firm experiences threats in its environment, for example resource similarity, that compel the firm to shift its network position.

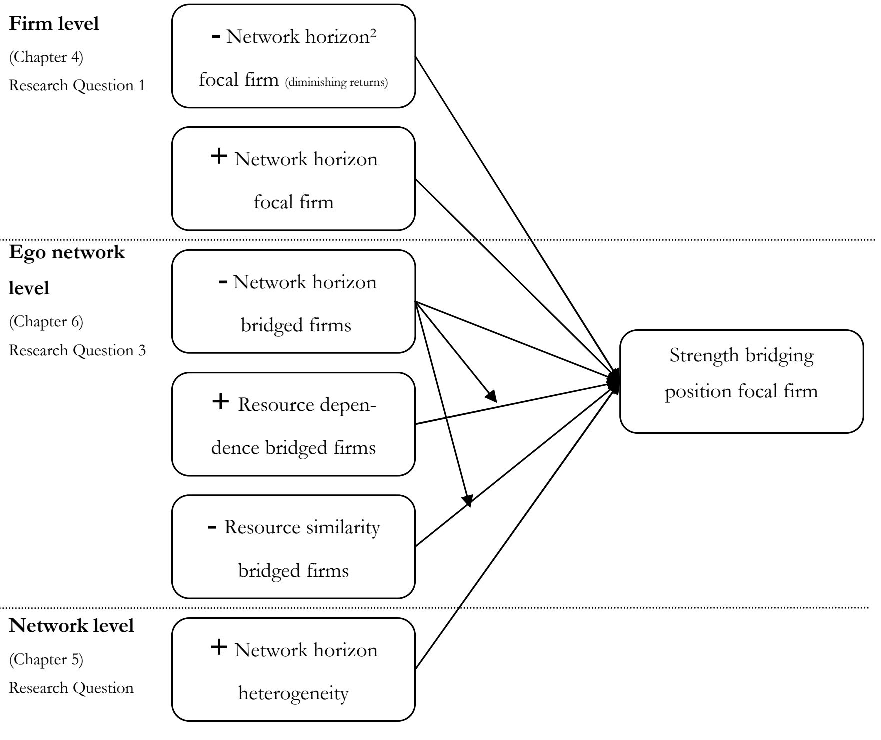

Figure 7-1 Model of the strength of a bridging position[49]

Network horizon is a firm level attribute, resource similarity is a partner firm level attribute, and network horizon manifests itself at the network level as network horizon heterogeneity. We have demonstrated that the heterogeneity is an important predictor of the level of competition for favorable network positions.

Network horizon becomes important when competition moves from the firm-level to the network-level. Industries like airlines, computer, insurance, microprocessors, and global technological standards face network-based competition. The resource-based

[49] The two arrows from 'network horizon bridged firms' to the arrows between resource dependence and resource similarity and the strength of bridging position of the focal firm should be interpreted as moderators. Thus, network horizons of the bridged firms reinforce these relationships. Thus, bridged firms with a high level of resource similarity and an extensive network horizon are even more susceptible to weaken the bridging position of the focal firm.

view alone cannot explain competitive advantage in such situations and hence the need for a network-based view of competitive advantage arises. An extended network horizon gives the edge in such competitive environments because changes in the structure and composition of rival networks cannot remain hidden. Changes in the structure and composition of a rival network predict future strategic actions (Gnyawali et al., 2006) and firms with extended network horizons stay aware of these changes and can (re)act more decisively to overcome competitors.

A network-based view of competitive advantage recognizes that not only resources controlled by a firm can generate a competitive advantage but that resources jointly controlled (Lavie, 2006) and the network position itself become potential sources of competitive advantage. These network resources (Gulati, 1999) can be even more effectively deployed when a firm expands its network horizon. Firms with extensive horizons locate quicker entrepreneurial opportunities compared with "blind-folded" firms. While the relational view (Dyer & Singh, 1998) acknowledges that an interfirm relationship itself functions as a source of competitive advantage, this research contributes by explicating the conditions (network horizon, network horizon heterogeneity, resource similarity and resource dependence) under which a network position, i.e. the *configuration* of interfirm relationships, and in particular the bridging position create a network-based competitive advantage.

Stinchcombe stated in his *Constructing Social Theories* (1968: 3) that "Theory ought to have the *capacity to invent explanations*"[50]. The network-based view, compromising of concepts like network strategy, network resources, network horizon and network position open up the possibility of inventing new explanations, as this study has demonstrated, and to view and understand firm behavior and performance from a network perspective.

7.3 Model of the Dynamics of Network Positions

This dissertation investigated several information-based explanations of the dynamics of bridging positions. These findings suggest a starting point for a more a general theory of the dynamics of network positions. In this section, we outline the contours of such a theory. This model consists of four phases. First, the current network position and composition of the capabilities of the focal and its partner firms give the

[50] Italics in original.

incentive for the focal firm to shift. The opportunities and threats that are present in the network (as demonstrated in Chapter 6) give the impetus to change. An incentive to change is a necessary precondition, but in itself insufficient. Network horizon is required to locate potential partner firms as was demonstrated in Chapter 4 and 5. Then, and this phase has not been covered by this study, comes the actual phase of partner selection. Which firm does the focal firm approach, negotiate with and close a deal with in order to establish an interfirm relationship. In our studies, we assumed that the focal firm does not face uncertainty about the partner firm it chooses. Recent research suggests that the partner selection phase is surrounded with uncertainty (Shipilov et al., 2006).

Establishing a new interorganizational relationship is surrounded with two types of uncertainty (Podolny, 2001). The first type of uncertainty is about the capabilities and resources the potential partner firm possesses. Determining the resources and capabilities of a firm is a complex process because these resources and capabilities are often hard to observe and little public information is available about them. Information about these capabilities and resources will often be disclosed after the interfirm relationship has been established (Gulati & Gargiulo, 1999). Firms can turn to their alliance partners to gather information about the reliability, competencies, and resources of potential partners (Baum et al., 2003). The second type of uncertainty is how the new partner firm will behave in the future after establishing the interorganizational relationship (Gulati & Gargiulo, 1999). The uncertainty regarding a firm's future behavior can be reduced by increasing the shadow of the future (Axelrod, 1984), embedding this particular relationship within a web of embedded relationships which act as a reputation mechanism (Coleman, 1988) or creating an appropriate governance structure (Gulati & Singh, 1998).

These two types of uncertainty can be reduced using different sources of information. First, uncertainty about the capabilities and resources of a potential firm can be reduced by looking at the partner firms of the new partner firm (Podolny, 2001). This view is referred to as the network as prism view. Firms that are similar (in terms of size, quality, or status) are more likely to collaborate with each other. If a network functions as a prism then other firms can infer from the new collaboration that the new unknown partner firm is likely to possess similar characteristics as the known firm. A second method to reduce the uncertainty about the capabilities and resources of a potential firm is for the focal firm to turn to its network to collect information about its future partner. Current partner firms might have interacted with the new partner firm and therefore have valuable information for the focal firm about its capabilities, resources, and behavior. Gulati and Gargiulo (1999) argue that the current interfirm network functions as a repository of information about a firm's capabilities and behavior, this information in turn shapes the decision the focal firm takes with whom to partner and this new relationship alters the network structure and changes the information repository. Uncertainty and equivocality (Daft & Lengel, 1986), a situation that is open for more than one interpretation, stimulate a firm to collect and process information about its environment in order to reduce uncertainty and increase clarity and interpretation of its environment.

Potential sources of information about the potential partner's behavior are the network itself because it functions as an information repository (Gulati & Gargiulo, 1999; Li & Rowley, 2002) and environmental scanning activities (Hambrick, 1982) can be used to reduce this type of uncertainty. If current partner firms have collaborated with the potential new partners then these partner firms are able to provide information about the potential partners' behavior. Second, organizational decision-makers engage in scanning and interpreting their firm's environment[51] (Hambrick, 1982) and can use this source of information in addition to turning to the network to collect information. Scanning a firm's environment is an important task of organizational decision-makers because it provides them with signals and information about the competitive intentions and actions of other firms (i.e. the behavior of the potential partner). Opportunities and threats are often used categories by organizational decision-makers (Jackson & Dutton, 1988).

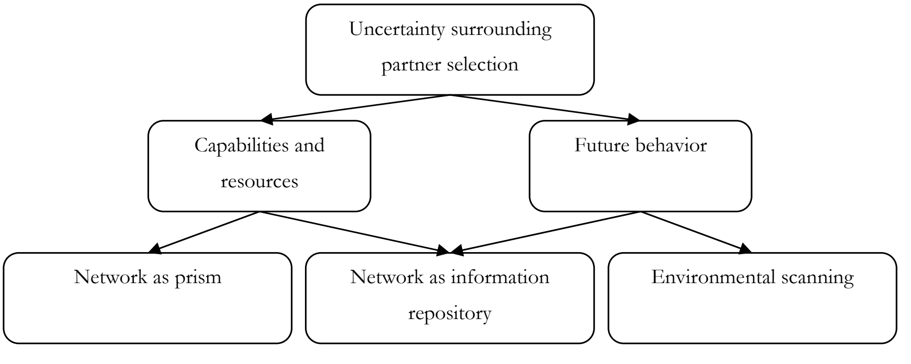

Figure 7-2 Information sources to reduce partner selection uncertainty

[51] For the purpose of this chapter is the interfirm network of a firm its environment. Obviously, the environment of a firm is much more extended than its network, but since the objective of this

Figure 7-2 Information sources to reduce partner selection uncertainty

The information source needed to reduce the uncertainty surrounding the new partner firm is moderated by the type of relationship that is established. If the potential partner firm will be reached through a local tie, (a firm that can be reached in fewer than two steps before the new relationship is established) then the network as information repository will suffice for collecting data. Figure 7-3 illustrates the difference between a local and non-local tie.

The network as prism and environmental scanning will not be needed because high quality information can be obtained from the focal firm's current partners. It would not be possible to use the network as information repository to collect data about a partner firm that will be connected to using a non-local tie because the focal firm's partners do not have any relationship with the non-local partner and therefore do not have any experience or any information about this non-local partner. In the end, a firm is chosen and the network position of the focal firm changes and so does the composition of the capabilities of its partner firms. This will in the short or long run lead to a new incentive for the focal firm to change its network position.

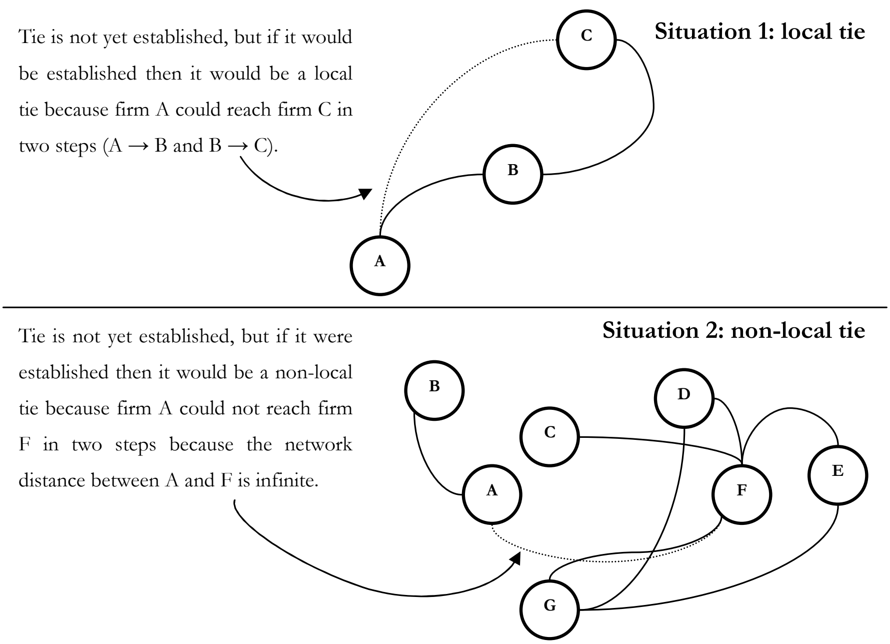

Figure 7-3 Illustration of the difference between a local and a non-local tie

This cycle is of course also applicable to all other firms in the network and cumulates into a continuous cycle of changes in the network. Figure 7-4 illustrates the model of network position dynamics. Although the robustness of our findings is strengthened by the multi-method multi-level longitudinal research design, there are still questions about the generalizability of these findings. Therefore, generalizability is the topic of the next section.

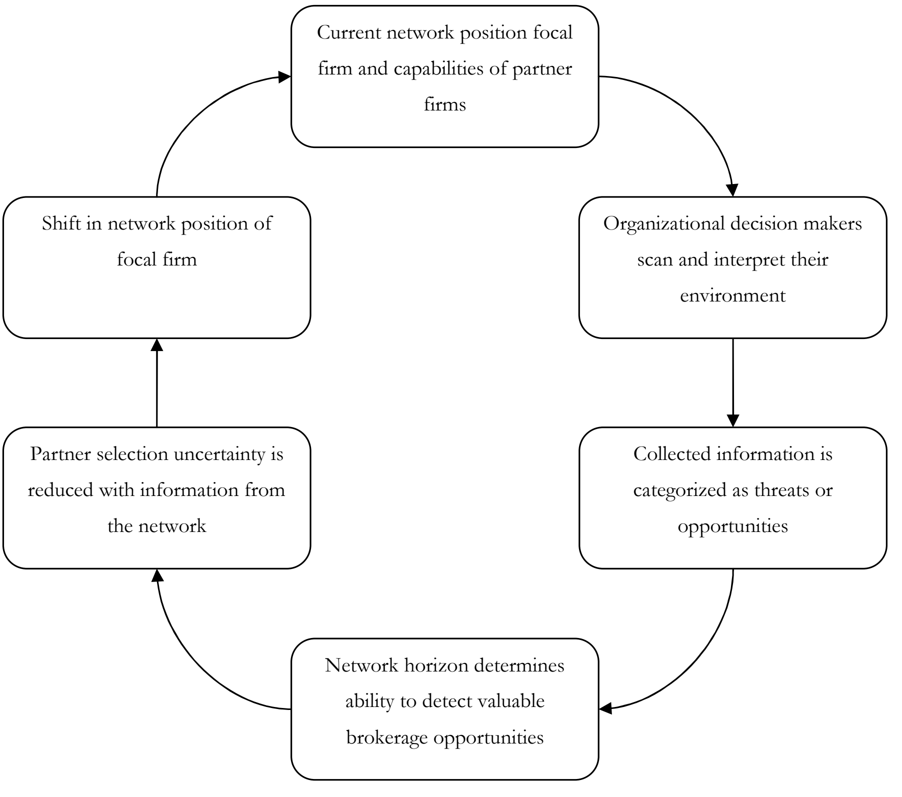

Figure 7-4 Dynamics of network positions

7.4 Generalizability and Limitations

We have findings from three different studies in this dissertation. To what extent are the findings of the network experiments and computational model generalizable to the insurance industry and to other industries? We employed a multi-method research design to increase both the internal and external validity (i.e. generalizability) of our results (Mingers, 2001).

Generalizing a finding beyond the context in which it was found is a major concern for organizational scholars. Lee & Baskerville (2003: 233) identify four types of generalizability: 1) generalizing from data to description, 2) generalizing from description to theory, 3) generalizing from theory to description and 4) generalizing from concepts to theory. The first type of generalizability often involves statistical generalizability when descriptives of a sample are used to make statements about a population. We will not attempt this type of generalizability in this study (except for the field study of Chapter 6), however; we will generalize from description to theory and from theory to description (because this is important for managerial relevance and will be done in section 7.4). The fourth type of generalizability (generalizing from concepts to theory) is not appropriate because this is an empirical study and not a theoretical study.

While a multi-method research design is aimed at overcoming internal and external validity concerns, some generalizability issues need to be addressed. We separate issues that apply to the whole study from issues that are particular to an individual methodology. We address five issues of generalizability that apply to the whole study, namely the focus on bridging positions, the operationalization of network horizon, the focus on unilateral dependence restructuring, the exclusive focus on the structural embeddedness perspective and an alternative explanation why firms might occupy bridging positions. Next, we address specific limitations that are particular to each research method.

The first limitation of this study is that we tested investigated the dynamics of network positions only for the bridging position. Chapter 2 also reviewed the benefits of a closed network position. Because the bridging and closed network positions differ on three crucial dimensions (value creating mechanism, emergence of the position, and the boundary conditions as we argued in Chapter 2), it seems premature to generalize our findings to other network positions such as the closed network position. At the same time, it seems likely that network horizon and interdependence also matter in those settings. Although we do expect that network horizon will play a less important role in understanding the dynamics of a closed network position because closed positions are often the result of past and referral partnering processes.

Second, we think that network horizon is a useful new construct for understanding why firms shift their network position - as the first two empirical chapters demonstrate. Our results should not be interpreted in terms of the effect size of the coefficients, but should be generalized as theoretical constructs (Lee & Baskerville, 2003) that partly explain differences in network positions. Because we have not conducted this study in a field setting, it is not possible to make statements about how large the effect is of network horizon and network horizon heterogeneity for real world firms. This study, does however, demonstrate that the ability of a firm to shift its network position is partly determined by its network horizon and by the network horizon heterogeneity. Triangulation of methods challenges the researcher to use different operationalizations of the independent variable depending on the researched context. In fact, using different operationalizations can significantly increase the internal validity of the research (Singleton, Straits, & Straits, 1988). Table 7-1 summarizes how in each context we operationalized the network horizon.

Research Context	**Operationalization**
Network Experiments	Network horizon is operationalized as the number of firms the focal firm knows by counting the firms that can be reached in k steps.
Computational Modeling	Network horizon is operationalized as the number of firms and their relationships the focal firm knows by counting the alters and their relationships a firm can reach in k steps and a random term.
Field Study	We did not operationalize network horizon.

Table 7-1 Different operationalizations of network horizon

The first operationalization is a network-centric operationalization while the second operationalization is more firm centric. The network-centric operationalization might be easier to replicate in an empirical context compared with the firm-centric operationalization. The network-centric operationalization could be translated in an empirical context as the percentage of firms of the total network that can be reached in two steps, which is consistent with Friedkin's horizon of observability (Friedkin, 1983). A firm-centric operationalization is more time consuming because it entails collecting data for each individual firm what it knows about the network structure. This daunting data collection process is furthermore complicated through the cognitive embeddedness (Baum et al., 2003) of organizational decision-makers. Cognitive embeddedness blurs the distinction between perception and information about the network. This can potentially result in overestimating the network position of powerful firms because they are more visible and underestimating the network position of peripheral firms because of their lack of visibility. Theoretically, there is no objection to use this construct in other empirical contexts. Although we were not able to measure network horizon for the insurance brokers and insurance firms (in Chapter 6), we do believe that this is possible in future research. Hence, this raises the question of how to measure network horizon in an empirical setting. Previous research suggests that the composition of the top management team has a positive impact on the rate a firm establishes new alliances (Eisenhardt & Schoonhoven, 1996). For example, team size, number of previous employers and previous highest job level have a positive influence on the propensity of a firm to enter a new alliance. These three indicators are possible items to measure a firm's network horizon. Once the individual network horizons of firms in an interfirm network are measured then it is rather easy to measure network horizon heterogeneity.

Third, we limited ourselves, in Chapter 2, to focus exclusively on unilateral restructuring of resource dependence (Pfeffer & Salancik, 1978). Suppose, we had also taken into account bilateral restructuring of resource dependence, how would have that affected our results? Bilateral restructuring aims at reducing uncertainty due to asymmetric dependence between two firms (Pfeffer & Salancik, 1978). Two broad strategies exist: 1) reducing the asymmetric dependence by increasing the focal firm's dependence on its partner or 2) by strengthening the bonds between two firms through taking joint seats in the board of directors, strengthening the collaboration through formal and informal agreements at multiple levels of the organizations or to take minority stakes in one of the companies. These are all strategies aimed at reducing behavioral uncertainty and hence to increase the predictability of the future of both companies. Such bilateral actions are more likely to result in a closed network position because of the increased collaboration compared with unilateral restructuring of resource dependence.

Fourth, we also limited ourselves, in Chapter 2, to the structural embeddedness perspective to study interfirm networks while there is a relational and cognitive embeddedness perspective as well (Baum et al., 2003). The structural embeddedness view focuses exclusively on how firms are connected to each other and does not study what flows through these relationships. Hence, if we had studied bilateral restructuring strategies then it would have been appropriate to take a relational embeddedness account. Relational accounts of interfirm networks are often confined to smaller network studies due to the extensive data collection efforts. However, a relational study would have uncovered directly the motives of a firm to shift its network position and would have made it possible to study what organizational decision makers know of their interfirm networks. The cognitive embeddedness perspective emphasizes that decision-makers focus their attention on firms with similar characteristics and use information cues from the environment to simplify the processing of information. Such a perspective represents a promising avenue which we will discuss in more detail in the future research section.

Finally, a status-based (Podolny, 1993) explanation comes to mind that explains why some firms span more structural holes than other firms do. Some industries are characterized by a status hierarchy. Firms with a high status have greater discretion when choosing to partner with another firm because such a firm is more attractive. Establishing bridging ties is usually associated with uncertainty (Baum et al., 2005). Firms with high status can overcome this uncertainty because they are perceived to be more trustworthy and reliable. Hence, firms with high status will span more structural holes compared with firms with low status. Although this explanation might be applicable in some industries, it did not play a role in either the network experiments or the simulation. We did not model status hierarchies in the network experiments nor in the simulation because the insurance industry is not a status-based industry. In the following section, we will address specific generalizability concerns for the individual methodologies.

7.4.1 Limitations of the network experiments

First, an important limitation of our network experiments is that our simulated firms were managed by individuals while in companies decisions are often made by teams and these decisions are passed up the hierarchy for an ultimate fiat. For example, theory on the upper echelons of organizations (Hambrick & Mason, 1984) predicts that demographic characteristics of organizational decision-makers influence the strategic actions that will be taken by a firm. Our random assignment of the treatment to the participants has effectively ruled out any systematic influence of demographic characteristics on the strategic actions taken during the experiments. The results of our experiments are not biased in one particular direction due to demographic characteristics because we controlled for them but our network experiments do not capture the decision making, information filtering, and interpretation processes that are characteristic for top management decisions. Decisions in a firm are often made by numerous people at different levels that coalesce in joint action. As such, our experiments do not replicate firm behavior but assume a hierarchical organizational structure in which decision-making politics, different constituencies, and intra-group decision making processes do not play a role. This limitation can be addressed by conducting on site research that investigates how management teams decide on shifting their network position.

Second, participants of the network experiments could not decline establishing a relationship with another firm, this is sometimes referred to as a 'non-cooperative' game (Bala & Goyal, 2000). This implies that a firm's network position can shift without the consent of the participant. However, we think that the implication of this is marginal.

Each participant aims at managing the most profitable firm in the network and thus partnering decisions are taken that are expected to improve firm performance. If a firm establishes a new relationship with a new supplier (without consent of the supplier) then it is safe to assume that the supplier offers capabilities at a lower price then other firms in the network. Thus, the firm establishing the relationship is expecting to reduce its procurement costs while the supplier expects to increase its turnover. Hence, both firms will benefit from this partnering decision even tough the non-focal firm did not give explicit permission to establish this relationship. Future network experiments can be organized as a cooperative game, by allowing participants to accept a new relationship, to study the impact on the dynamics of network positions.

Third, students without industry knowledge or insurance background may not be proper substitutes for real-life managers in conducting our network experiments. We tried to minimize the impact of this effect using three solutions: 1) we invited insurance brokers and middle managers from an insurance firm to participate in the experiments as well, 2) we gave the students monetary incentives to act in a way to maximize the financial performance of the firm and hence to stimulate to action as rational as possible and, 3) we used a student team with fixed members to control for learning effects.

7.4.2 Limitations of the computational model

First, the validation of the simulation model is important. The limitation of a computational model is that the model is as strong as it representation of an empirical setting. Two steps were taken to increase the external validity. First, we used the roadmap for developing theory using simulation methods by Davis et al. (2007) to validate the computational model. In particular, we focused on verifying the utility function in the computational model in order to create a realistic representation of partnering behavior of firms in the real world. Second, we used different utility functions during the test phase with different threshold values whether a firm should accept a new tie (see Validation of computational model in Chapter 3). We used the utility function where the partnering behavior in the computational model results in sparse networks, a feature that is common for interfirm networks (see Table 3-4). Furthermore, we replicated the simulations to determine whether the findings are robust. We did not find great differences compared with the results presented in this chapter.

Second, an alternative explanation that some firms might span more structural holes than other firms is because they possess unique and valuable resources that are scarce and hence they are more attractive to partner with. In the network experiments, we did control for resource dependence factors including the focal firm and partner firm attractiveness (variables fourteen and fifteen in Table 4-2). In the computational model, we modeled each firm as a homogenous actor. There were no firm specific differences between the firms in the simulation and hence we controlled for resource dependence factors that might influence the number of structural holes a firm spans.

7.4.3 Limitations of the field study

First, resource dependence and resource similarity are measures that have often been calculated in diverse empirical contexts (Casciaro & Piskorski, 2005; Chen, 1996; Pfeffer & Salancik, 1978). However, a limitation is that the indicators we used in this research for resource dependence and resource similarity are dependent on firm and industry characteristics. For example, we could construct resource similarity matrices because the capabilities were relatively easy to decipher. In other industries, were products are maybe more integrated, the construction of such resource similarity matrices can be more difficult.

A second limitation is that the insurance brokers we studied in the field study of Chapter 6 are significantly larger (in number of employees) compared with insurance brokers that do not belong to the Insurance Data Network. This selection bias suggests that our findings potentially are only applicable to medium and large insurance brokers. Smaller insurance brokers possibly lack the resources to shift their network position but this should be investigated before reaching conclusions.

The final limitation is that we studied a vertical network in the field study. In vertical networks is the importance of brokering information negligible while the control benefits are much more important. For example, an insurance firm is not brokering information between two insurance brokers because if an insurance firm would broker information from one broker to another broker it would make the position of the brokers stronger because of the increased information availability. However, an insurance firm does have control benefits by executing the tertius gaudens.

Overall, the findings of the three studies are consistent with each other and therefore we conclude that network horizon, network horizon heterogeneity, resource dependence, and resource similarity are important determinants of the dynamics of bridging position.

7.5 Contribution to Literature

This study has three contributions to the existing literature on interfirm networks. First, we add a dynamic perspective to the mainly static theory of structural holes. By adding a dynamic perspective, we move away from network effects and investigate network processes, something network scholars have been advocating for a long time (Kilduff et al., 2006; Salancik, 1995). Second, we developed an explanation based on the availability and distribution of information about the network structure and how this impacts the dynamics of network positions. Such an information-based view of network dynamics is consistent with the approach suggested by Moldoveanu et al. (2003). Third, a major strength of our research is that we used three different research methods to study longitudinal the dynamics of network positions. Furthermore, the research design that includes multi-level in combination with the longitudinal data responds to calls for more rigorous and longitudinal analysis of network dynamics (Baum et al., 2005; Gulati et al., 2000; Zaheer & Usai, 2004). Our causal explanations are stronger compared with cross sectional research designs due to using experiments that aim at establishing causality and lagging our independent variables in the field study. This in combination with advanced estimation techniques minimizes the risks of biased parameter estimates.

The contribution of this research extends beyond the literature on interfirm networks, we will also draw two implications for the IS literature. Our information-based explanation is especially relevant for the IS field because it represents an opportunity to study how information and information technology influences the emergence, governance and execution of interfirm networks. First, we argued that communication technologies enable a transformation of previous static chains into more dynamic networks. In particular, quick connect capabilities have the potential of changing the business landscape and future research about this topic is needed (we will go in more detail in the future research section about this topic). Second, we argued that specialization and modularization would lead to an increased use of interfirm networks. Coordinating modular processes and products in an interfirm network will become an increasingly important topic of research as is indicated by recent research (Hoetker, 2006; Karim, 2006; Pil & Cohen, 2006). A possible suggestion is to adopt actor-network-theory (Law, 1992) to study the interaction of social relationships and artifacts and how this influences a firm's network position and the overall network structure.

7.6 Managerial Relevance

We discuss four managerial implications of this research: first the importance of network horizon, second the need for a network vocabulary, third the importance of a network strategy, and fourth the growing importance of network based competition. Network horizon is an important concept for organizational decision-makers because it improves locating profitable business opportunities in the network. Firms have limited resources to maintain interfirm relationships and once a firm has gained access to required resources, it has a smaller incentive to establish new relationships. This in combination with the fact that many interfirm relationships are characterized by a 'honey-moon' period (Levinthal & Fichman, 1988) which reduces the probability of an interorganizational relationship being terminated early on. Finally, to enter a new interorganizational relationship a "firm must have resources to get resources" (Eisenhardt & Schoonhoven, 1996: 137). Thus, a path dependent process makes it more likely that firms that establish an interfirm tie first are more likely to continue reaping the benefits from such a relationship. Hence, it is worthwhile to actively monitor and use the network to identify potential future partners.

Second, managers should expand their vocabulary and understanding of networks in order to reap the benefits of network horizon and a network strategy. It is important for organizational decision-makers to understand that their firm is embedded in an interfirm network. The position in the network influences what decision makers know of the network and what organizational decision-makers know of the network influences their network position. Understanding how a firm is embedded in a network has also implications for decision makers for what the kind of actions they can or should take, and how this affects firm performance. The make or buy decision increasingly becomes the make, buy or ally decision (Jacobides & Billinger, 2006). When a firm chooses to ally, it becomes very important for a firm to decide which capabilities to specialize in and which capabilities to outsource to partner firms; this requires knowledge about the skills and resources of the partner firms. In order to increase their vocabulary, managers can use formal research methods. For example, the Business Network Engine can be used to increase the network awareness of management, teach managers elementary network concepts, and train managers in developing network strategies. This can result in real-world strategy development exercises. This is actually not a far-fetched suggestion: the Business Network Engine has been used to train middle managers of a large Dutch insurance firm in network thinking and this has resulted in the launch of a new business unit that sells car insurance policies using the Internet, designed according to the principles of the Business Network Engine.

Third, the emerging field of network strategy is still in its infancy mainly because we have a limited understanding to what extent organizational decision-makers are aware of their network position and to what extent they are purposeful when there is a shift in the network position (Rowley & Baum, 2004). In some industries, organizational decision-makers are very aware of the importance of their networks, for example investment banks or biotechnology firms. In other industries, the awareness increasing is, for example in the insurance industry. Heightened awareness of the importance of the overall network and the particular position a firm occupies in this network will increase the need to monitor the network more closely in order to envisage changes in the network and the possible consequences.

A firm is less likely to be surprised by competitor moves when it incorporates the interfirm network in the environmental scanning activities. According to the 'awareness – motivation – capability' perspective (Chen et al., 2007; Chen, 1996) awareness (or network horizon in this study) is a crucial first step to be able to respond to competitor moves. A firm can prepare itself against these competitor moves by formulating a network strategy. Such a network strategy aims at protecting current interfirm relationships, identifying and analyzing potential partners and monitoring the interfirm network.

A possible first step in devising such a network strategy is to translate the well-known operational excellence, product leadership and customer intimacy strategies (Treacy & Wiersema, 1993) into their network complements. A network-based version of operational excellence could be that a firm specializes in a limited set of capabilities and establish links with competitors or with firms from adjacent industries. An example of this would be the opening of shared service centers for competitors. A network-based customer intimacy strategy could be to become a network orchestrator (Hinterhuber, 2002) or network architect (Pollock et al., 2004) and build a strong bridging position that allows the network orchestrator to fulfill any demand of its customers. Finally, the network-based version of product leadership could be to build an effective interfirm network that is both highly efficient in the production and refinement of current products while simultaneously being able to innovate. A particular suitable network position for such a strategy would be the hybrid (Baum et al., 2006) network position: this position gives the benefits of bridging (access to new ideas to innovate (Burt, 2004)) and the benefits of embeddedness (transfer of thick information to improve current processes (Hansen, 1999)). Such a network may be able to balance the demands for exploitation and exploration (Lavie & Rosenkopf, 2006). This brings us to the fourth point and implication for managers: network-based competition.

Fourth, competition between networks will become more and more important as firms become more dependent on their interfirm network for a competitive advantage (Gnyawali & Madhavan, 2001; Lavie, 2006). Network-based competition can already be witnessed in the airline industry (Gimeno, 2004) with alliances competing against each other and the computer industry in, for example, different competing platforms (Venkatraman & Lee, 2004) and different competing processors (Gomes-Casseres, 1996; Vanhaverbeke & Noorderhaven, 2001). This type of competition will increasingly become more important, and to be able to win this type of competition it will become crucial to be knowledgeable about the capabilities and resources of the partner firm and the strategic actions that the competing networks are initiating. This will make the network horizon of a firm even more important.

Finally, interorganizational information systems (IOS) will increasingly become more widespread to manage and monitor interfirm networks. The monitoring of the network makes it possible to develop Key Network Performance Indicators (KNPI's) to increase the efficiency and effectiveness. With these KNPI's an information dashboard can be built to monitor continuously the performance of both the firm and the network.

7.7 Directions for Future Research

We will conclude this dissertation with some suggestions for future research; particularly focusing on the intersection of IS and interfirm networks. Topics that we cover in this section are the information architecture of interfirm networks, evolution of market and embedded relationships, network cognition, network strategy, network position endogeneity, dynamics of interfirm networks and network performance.

7.7.1 Adoption of quick connect capabilities

Recent technological developments make it easier and cheaper to maintain, electronically, more relationships. Such relationships are very efficient for the transmission of standardized transaction. However, these types of relationships possibly undermine the more informal relationships between buyers and suppliers because the need for personal communication is reduced through Internet self-serve technologies

(Schultze & Orlikowski, 2004). Schultze and Orlikowski (2004) argue that previously embedded relationships are endangered by the adoption of such technologies and found that these self-service technologies threatened the business model of the company they studied. From an economic point, there is a strong case to be made to adopt these technologies because of higher efficiency and fewer errors in the communication between firms (van Liere et al., 2004). From a sociological point, there might be drawbacks because previously embedded relationships become weaker and will function less as a source of joint problem solving and thick information transfer (Schultze & Orlikowski, 2004). Previous research suggests that these electronic relationships and embedded relationships are complimentary (Kraut, Steinfield, Chan, Butler, & Hoag, 1999). Future research can investigate, from a longitudinal perspective, how the adoption of quick connect capabilities impact embedded relationships and investigate under what circumstances embedded ties can be maintained while still profiting from the benefits from the electronic linkages.

7.7.2 Information architecture of an interfirm network

Effectively managing a business network will be a key concern for organizational decision makers in the coming years. A key ingredient to manage effectively these networks is to define an interfirm network information architecture. This information architecture defines which information is available to whom, when and under what conditions (Koppius, 2002). As a network grows larger, the need for such an information architecture will only increase. A larger network is more complex to manage as the number of potential relationships increases exponentially. Who is allowed to have access to what information becomes crucial: information should be available to the people who need it and vice versa. Studying the antecedents and consequences of an interfirm network information architecture can increase our understanding of how to manage effectively an interfirm network.

7.7.3 Evolution of market and embedded relationships

The previous suggestion for future research leads us to our second and related suggestion. Previous research has extensively documented the benefits of market and embedded relationships (Granovetter, 1985; Uzzi, 1997; Williamson, 1975). However, where do embedded and market relationships come from and how is their existence related? There are two implicit assumptions underlying the embedded / strong vs. market

/ weak relationships. The first assumption is that a tie is always utilized to its fullest potential; the second assumption is that there is a continuum from market / weak to embedded / strong tie. The view that the strength of a tie is a continuum is debated. Some authors argue that it is a continuum (Marsden & Campbell, 1984) while others (Rowley et al., 2000; Uzzi, 1996) argue that these are two distinct types of relationships. The fact that a tie exists does not necessarily mean that it is always used or is used to its fullest potential. The strength of ties debate illustrates this implicit assumption, characterizing the form of a tie (strong or weak) does not describe the substance of the tie. What kinds of resources or information are actually flowing through this relationship? This should be measured separately in order to get results that are more consistent. Although form and substance might be correlated, this is not necessarily the case. The way Granovetter (1973) defined the strength of a tie is consistent with the continuum view. His definition raises the problem that through time there is a natural evolution from a weak tie towards a stronger tie and that there is natural regression from strong ties to weaker ties unless a continuous effort is put in the relationship to keep its strength. Thus, by utilizing a weak tie often to acquire new information would in essence mean that the tie evolves to a stronger tie and thereby the information benefits are foregone. The best way to keep a weak tie as a weak tie is by not utilizing the weak tie. The same is true for a strong tie; by not utilizing the tie frequently the tie would become weaker. Taking the view that in fact there is no continuum but we are dealing with two distinct types of ties then we do not have the problem of natural evolution or regression. Strong ties can become dormant and latent and reactivated when needed (Jack, 2005) without becoming a weak tie. Once a tie has a particular strength it remains stable, for example, acquaintances stay acquaintances and do not necessarily turn into friends. Hence, an interesting future research question is: under what circumstances do weak ties become strong ties and strong ties become weak ties?

7.7.4 Network horizon and network cognition

We explicitly assumed that the information firms have about their network structure is accurate. However, research at the individual level suggests that this might be too strong an assumption and that there are cognitive biases in how individuals collect and process information about the network structure (Casciaro, 1998). Consequently, our third suggestion for future research is to investigate to what extent organizational decision-makers have information about the network structure and to what extent they are acting in a strategic way when deciding with whom to partner. Previous research suggests that the demographics of the top management team play a role (Eisenhardt & Schoonhoven, 1996; Sutcliffe, 1994). We suggest two avenues to research the network horizon of a firm in an empirical setting. First, future research could take a more detailed look at the composition of a top management team and their networking activities through board interlocks and business associations. Second, researchers can adopt a cognitive approach in which organizational decision-makers are interviewed and asked to draw a map of the network structure. This is consistent with previous work on cognitive models of industry structures (Porac et al., 1995).

7.7.5 Network strategy

There is a strong instrumental assumption underlying structural hole theory, Burt (1992: 2) phrases it as follows: "players know about, take part in, and exercise control over more rewarding opportunities". Burt weakened this assumption in later work (2005) and he seems to be unconvinced that individuals are able to purposefully shift their network position. However, firms have more resources available and decisions are made after careful consideration of alternatives. Hence, an interesting avenue for further research is to what extent firms *have* a network strategy and the elements that constitute a network strategy. This research focused to what extent firms know about more rewarding opportunities and showed the implications of different levels of information. However, less research has focused on the instrumental aspects of this assumption. Do organizational decision-makers think in terms of their network position and the benefits they receive? Do organizational decision-makers consider the effect of a partner decision on their network position? Do organizational decision-makers monitor the network actions of their partners and respond to these actions?

7.7.6 Endogenous changes in network positions

Future research could address the important issue of firm position endogeneity. Decision-makers do not randomly decide but make decision that they expect will have the most positive outcome (Hamilton & Nickerson, 2003). If this is true, then a shift in a firm's network position is a self-selected strategy that is expected to create the greatest benefits for the firm. In the context of network research, endogeneity raises the issue whether firm performance leads to a strong network position or does a strong network position influence firm performance? There is causal ambiguity, and possible reverse causality, between the relationship firm performance and network position. This is an important problem because it obscures what firms should do in order to improve their network position.

7.7.7 Interfirm network topology evolution

A possible extension of the applicability of the network horizon and network horizon heterogeneity is to develop an interfirm network formation mechanism based on the availability and distribution of information to study the emergence of network topologies. For example, two distinct firm characteristics could be hypothesized to be mainly responsible for the emergence of a network topology. The first characteristic is the individual network strategy of a firm; what type of network position does each firm pursue, and what are its organizational partnering tendencies? The second characteristic is the multi-level construct network horizon. Different mixes of network strategies and different levels of network horizon heterogeneity could lead to different network topologies. Such a network formation mechanism is consistent with the approach suggested by Moldoveanu et al. (2003).

7.7.8 Network performance

Research on network performance is nascent but will become an increasingly important topic as competition will be increasingly network based. Future research should focus on two aspects of network performance: 1) the definition and operationalization of network performance (Straub et al., 2004) and 2) the antecedents and consequences of network performance. In particular, the competition within and between networks is fascinating since it requires a balance of competition and cooperation between firms (also referred to as coopetition (Brandenburger & Nalebuff, 1997)).

7.8 Concluding Remarks

In conclusion, studying the dynamics of network positions increases our understanding of where bridging positions come from and why structural holes that are spanned by bridging positions exist. This increased understanding can benefit both network scholars and practitioners alike. With the increasing importance of network-based competition, network strategies, and the need for a network vocabulary, we can only conclude that both scholars and practitioners should keep expanding their horizon.

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Nederlandstalige Samenvatting (Dutch Summary)

Het doel van dit proefschrift is om inzicht te verschaffen in de oorzaken van dynamiek van netwerk posities van bedrijven. Terwijl de voordelen van netwerk posities veel aandacht hebben gehad in de literatuur over bedrijfsnetwerken zijn de processen die ten grondslag liggen aan dergelijke posities onderbelicht gebleven. Netwerk posities creëren een voordeel doordat ze bedrijf toegang geven tot waardevolle en schaarse middelen. De configuratie van interorganisatorische relaties bepaalt wat voor type positie een bedrijf inneemt. Twee bekende en vaak bestudeerde posities zijn de brugpositie en de gesloten positie. Een bedrijf neemt een brugpositie in wanneer haar partners niet direct met elkaar verbonden zijn, er zijn zogenaamde *structural holes* tussen de partner bedrijven. In tegenstelling, een bedrijf neemt een gesloten positie in wanneer haar partner bedrijven wel met elkaar verbonden zijn, er zijn geen *structural holes* tussen de partner bedrijven. Elk type positie kan waarde creëren voor een bedrijf, echter deze mechanismen zijn tegengesteld aan elkaar. Een bedrijf met een brugpositie creëert waarde door gebruik te maken van informatie asymmetrie tussen de partner bedrijven terwijl een bedrijf met een gesloten positie waarde creëert door informatie asymmetriën te verminderen en daardoor effectieve sanctiemechanismen, gedeelde mentalen kaarten en effectieve reputatie mechanismen creëert.

Veranderingen in netwerk posities, door het aangaan van nieuwe interorganisatorische relaties of het verbreken van oude, hebben effect op het gehele netwerk en kunnen resulteren in het aangaan van nieuwe interorganisatorische relaties van andere bedrijven. Deze constante veranderingen van relaties zijn de motor achter de dynamiek van netwerk posities. We nemen de brugpositie als start punt en onderzoeken factoren die bijdragen aan het versterken, verzwakken en duurzamer maken van deze positie. We maken gebruik van een multi-methode, multi-level, longitudinale onderzoeksopzet met als onderzoeksmethoden netwerk experimenten, simulatie, en een veld studie.

Het versterken van een brugpositie vereist informatie van de netwerk structuur om een bedrijf in staat te stellen waardevolle *brokerage* kansen te identificeren. We introduceren het concept van *netwerk horizon* en definiëren het als de mate van informatie die een bedrijf heeft over het bedrijfsnetwerk op een gegeven moment. Gebruikmakend van netwerk experimenten en simulatie demonstreren we dat bedrijven met meer informatie over de netwerk structuur beter in staat zijn *brokerage* kansen te lokaliseren en daarmee in staat zijn hun brugpositie te verstevigen. Daarnaast vinden we dat er afnemende meeropbrengsten zijn van een netwerk horizon. Voorbij een bepaald punt loont het niet om nog meer informatie over het netwerk te verzamelen omdat het niet leidt tot een sterkere brugpositie. Echter, niet alleen het geanalyseerde bedrijf heeft een netwerk horizon, de overige bedrijven in het netwerk hebben ook informatie over de netwerk structuur hoewel het waarschijnlijk is dat deze bedrijven andere informatie bezitten. Daarom introduceren we een tweede concept namelijk dat van *netwerk horizon heterogeniteit*. Netwerk horizon heterogeniteit verwijst naar de verschillen tussen bedrijven in de hoeveelheid informatie die ze bezitten over de netwerk structuur. We demonstreren, met behulp van een simulatie, dat de netwerk horizon heterogeniteit een belangrijke voorspellende factor is voor de duurzaamheid van een brugpositie. In tegenstelling, netwerken die worden beschreven met relatief homogene netwerk horizon distributies worden gekenmerkt door intensievere concurrentie voor brugposities en daarmee wordt de duurzaamheid van een brugpositie verkort.

Afsluitend laten we zien, met behulp van netwerk experimenten en een veld studie, dat *resource similarity* en *resource dependence* belangrijke factoren zijn van de dynamiek van netwerk posities. *Resource similarity* verwijst naar de mate substitueerbaarheid tussen partner bedrijven, bedrijven met dezelfde middelen zijn meer substitueerbaar dan bedrijven met verschillende middelen. *Resource dependence* verwijst naar de onderlinge afhankelijkheid tussen twee bedrijven. Beide studies laten zien dat wanneer de *resource similarity* toeneemt, de concurrentie tussen partner bedrijven ook toeneemt en dat deze partner bedrijven nieuwe interorganisatorische relaties aanleggen om de toegenomen concurrentie af te zwakken. De veld studie laat zien dat afhankelijke bedrijven hun relatie met het bedrijf dat de brug functie vervult nog verder verstevigen, door andere interorganisatorische relaties af te breken, en daarmee nog afhankelijker worden van het bedrijf met de brugpositie.

Samenvattend, deze dissertatie draagt bij aan het onderzoek naar bedrijfsnetwerken door inzicht te verschaffen wanneer brugposities versterken, verzwakken of blijven bestaan. Dergelijke kennis is van belang voor zowel wetenschappers als praktijkmensen. Wetenschappers kunnen profiteren van deze kennis omdat het bijdraagt aan een beter begrip van netwerk-gebaseerd concurrentie voordeel. Praktijkmensen kunnen profiteren van deze studie omdat deze studie het belang van een *netwerk strategie* onderstreept dat een bedrijf nodig heeft om te overleven in een verbonden wereld.

Biographical Sketch

Diederik van Liere was born in Kortenhoef, the Netherlands, on February 18, 1978. He attended Herman Jordan Lyceum in Zeist, from which he received his Atheneum diploma in 1996. After high school, Diederik went on to study Business Administration at the Erasmus University Rotterdam, the Netherlands. In 1997, he founded his own Internet design company and was an exchange student at Brandeis University, Boston, United States, in 2000. In November 2002, Diederik received his Master's degree with a thesis on how the Internet transforms value chains into value networks.

In November 2002, Diederik became a PhD student at the Department of Decision and Information Sciences at RSM Erasmus University. In January 2006, Diederik went to the Rotman School of Management at the University of Toronto for six months as a visiting researcher. His work has been published in *Communications of the ACM*, *Decision Support Systems, Journal of Information Technology*, and *Production Planning, and Control*. Furthermore, a book chapter will appear in the *Network Strategy - Advances in Strategic Management* series. He has presented his research at major international conferences, such as the Academy of Management (AoM), Sunbelt, and European Conference on Information Systems. Moreover, he won the *Best Reviewer Award* for the Organization, Management, and Theory (OMT) Division of the Academy of Management in 2006 and currently serves as a member of the OMT Research Committee. Furthermore, Diederik serves as a reviewer for the Business Process and Strategy (BPS) Division of the AoM. His research interests focuses on dynamics of interfirm networks, network strategies, network cognition, and competitive rivalry within and between interfirm networks.

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Network Horizon and the Dynamics of Network Positions

A Multi-Method Multi-Level Longitudinal Study of Interfirm Networks

Why does the network position of a firm change? Which firm, partner firm, and network factors accelerate or slow down this change process? This is the central theme of this dissertation. The causal mechanisms behind the benefits of network positions have received considerable attention in academic research on interfirm networks. However, in most cases this research assumes a more or less static network. In today's world of advanced communications, interfirm networks are not static but highly dynamic where firms pursue beneficial network positions. A particular beneficial position is the bridging position that puts the bridging firm in-between its partner firms. Taking the bridging position as point of departure, this study investigates the strengthening, weakening and longevity of this position. A rigorous triangulation method has been used combining network experiments, simulation, and field data analysis with formal tools that have been specifically designed – as part of this study – to study interfirm networks (the Business Network Engine and LINKS). The concept of network horizon is being introduced to define the degree of information which a firm holds on the structure of its interfirm network at a given point in time. The size of a firm's network horizon is shown to be a critical determinant of the firm's ability to strengthen and keep its bridging position. This does not mean that a firm should always try to expand its network horizon as the study indicates a passing point: expanding the network horizon beyond this point gives rapidly diminishing returns. Interfirm differences in their network horizons, i.e. *network horizon heterogeneity,* is found to be an important predictor of the intensity of competition for network positions. Resource similarity between partner firms weakens the bridging position; and resource dependence strengthens the bridging position. In summary, it is being proposed that the most valuable network positions are ones that will not last long. This study has provided important tools and methods for rigorous future research that will be highly relevant for managers to develop successful network strategies to win the best position in a networked world.

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