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The Impact of Networking on Firm Performance

Evidence from Small and Medium-Sized Firms in Emerging Technology Areas

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Contents

Abstract

Recent developments in the field of network research have led to a growing interest in interorganisational relationships among social science scholars. One of the most important research areas is related to entrepreneurship research and how relationship networks affect firm performance. However, the existing literature focuses mostly on qualitative case studies and quantitative studies that analyse mergers and acquisitions or patent types of data.

By analysing connection and causality between activity in co-operational relationships and firm growth, this study seeks to empirically address the following research question: 'How does activity in network relationships influence the growth and internationalisation of technology-based firms in emerging technology areas?' Furthermore, the connection and causality between activity in co-operational relationships and the internationalisation rates of firms are also analysed.

This analysis is based on a data set and interviews with 53 small and medium-sized firms. Both a descriptive analysis and regression methods are used to analyse the connection between activity in co-operational relationships and firm growth or internationalisation. Firm growth is measured with both revenue and the employment growth rate. In addition, the activity in in the co-operational relationships is divided into two components: increasing versus consistently high activity with network actors. To address possible causality issues, this research employs activity measures that are based on the importance of the relationships rather than simply the number of relationships.

The results show that increasing activity with network actors is positively connected with firm growth as measured in both revenue and employment growth. Furthermore, the results partially support the hypothesis that consistently high activity is positively connected to firm growth. Finally, the results suggest that growth firms positively benefit from increased relationship activity with both current and prospective actors in diverse relationship networks. Moreover, the single most negative result is the relatively low impact of relationship activities on public-sector actors and networks.

Key words: Interorganisational relationships, firm growth, internationalisation, networks

JEL: L14, L25, L26, O43

Tiivistelmä

Viimeaikainen kehitys verkostotutkimuksessa on kasvattanut kiinnostusta organisaatioiden välisten suhteiden tutkimiseen sosiaalitieteiden tutkijoiden keskuudessa. Yksi tärkeimmistä tutkimusalueista on selvittää, miten yrittäjyystutkimus ja verkostosuhteet vaikuttavat yrityksen menestykseen. Tästä huolimatta olemassa oleva kirjallisuus koostuu pääosin vain laadullisista tapaustutkimuksista ja määrällisistä tutkimuksista, jotka analysoivat lähinnä yrityskauppa- tai patenttidataa.

Tämä työ tutkii yritysten yhteistyösuhteiden ja yrityksen kasvun välistä yhteyttä empiirisesti analysoimalla toimijoiden välisiä suhteita sekä vastaamalla tutkimuskysymykseen: "Miten verkostosuhteet vaikuttavat teknologialähtöisten yritysten kasvunopeuteen ja kansainvälistymiseen uusilla teknologia-aloilla?". Lisäksi työssä tutkitaan yritysten yhteistyösuhteiden ja kansainvälistymisen välistä yhteyttä.

Tutkimusta varten haastateltiin 53 suomalaisen pienen ja keskisuuren yrityksen edustajaa. Tutkimuksessa käytetään sekä kuvailevia että regressioanalyysin menetelmiä analysoimaan yhteistyösuhteiden ja yrityksen kasvun tai kansainvälistymisen yhteyttä. Yrityksen kasvua mitataan sekä liikevaihdon että henkilöstön kasvulla. Lisäksi aktiivisuus yhteistyösuhteissa jaetaan tutkimuksessa kahteen komponenttiin: kasvavaan ja jatkuvaan aktiivisuuteen verkostotoimijoiden kanssa. Tutkimuksessa huomioidaan mahdollisia kausaliteettiin liittyviä ongelmia luomalla aktiviteettimuuttujat yhteistyösuhteiden lukumäärän sijasta niiden tärkeyden perusteella.

Tutkimuksen tulokset osoittavat, että lisääntyvä aktiivisuus verkostotoimijoiden kanssa on positiivisesti yhteydessä sekä yrityksen että liikevaihdon ja henkilöstön kasvun suhteen. Tämän lisäksi tulokset osittain tukevat hypoteesia, että jatkuva aktiivisuus on positiivisesti yhteydessä yrityksen kasvuun. Tutkimustulokset myös viittaavat kasvuyritysten hyötyvän lisääntyvästä aktiivisuudesta sekä tulevien että nykyisten toimijoiden kanssa monipuolisessa verkostossa. Tulokset osoittavat myös, että julkisen sektorin toimijoiden ja verkostojen merkitys on aktiivisissa verkostosuhteissa vähäinen.

Asiasanat: Yritysten väliset suhteet, yrityksen kasvu, kansainvälistyminen, verkostot

1 Introduction

1.1 Background

Recent developments in the field of network research have led to a growing interest in interorganisational relationships among physical and social science scholars (Borgatti et al., 2009, Gulati et al., 2011). Furthermore, researchers have connected network research with entrepreneurship research to investigate how networks affect firm performance (Slotte-Kock and Coviello, 2010, Watson, 2007). For example, network theory suggests that network relationships provide access to otherwise unavailable resources and information and may thus have a positive effect on firm performance (Watson, 2007). To investigate the above process, this study examines the interorganisational networks of Finnish entrepreneurial firms in high-technology sectors. Moreover, this study contributes to the existing literature by empirically examining the connection between the evolution of interorganisational networks and firm performance, as the existing literature focuses on qualitative case studies and quantitative studies that analyse mergers and acquisitions or patent types of data. The measures that are used in this study to analyse the above connections are intended to describe the intensity of the relationships with certain actors rather than the number of relationships and thus contribute new insights to the literature.

An additional motivation for this study is the relatively small number of successful growth firms in Finland, particularly because Finnish governmental organisations, such as the Finnish Innovation Fund (Sitra) and the Finnish Funding Agency for Technology and Innovation (Tekes), have organised public funding programs to support growth firms in high-technology sectors. However, despite investments in these sectors, success has been moderate in recent years, especially in the renewable energy technology, environmental technology, and nanotechnology sectors, when success is measured in terms of patenting activity (Palmberg and Nikulainen, 2010, Palmberg and Nikulainen, 2006). This study provides insight into these issues by describing the networks of the studied firms and, more importantly, by examining how these networks have evolved during the last three years and determining which actors have assisted the interviewees in forming new network relationships. Understanding these issues is important because previous studies have argued that network relationship activity is positively associated with the success and survival of firms (Watson, 2007, Jack et al., 2008, Prashantham and Dhanaraj, 2010).

1.2 Research questions and objectives

The two main objectives of this study are to describe interorganisational network relationships and to study how these relationships affect firm performance in the context of Finnish small and medium-sized renewable energy technology, environmental technology, and nanotechnology firms. Therefore, based on the objectives above, the main research question can be presented as follows:

How does activity in network relationships influence the growth and internationalisation of technology-based firms in emerging technology areas?

This research question is operationalised through the hypotheses that are presented in Chapter 3.

To answer the research question, this study examines the existing literature to form a theoretical framework for the researched topics. This objective is achieved by establishing the theoretical framework in four stages. First, this research describes entrepreneurial networks and recognises the actors who interact in these networks. The second stage includes the study of network management and, more importantly, the evolution and dynamics of such networks. The specific aim is to identify the positive effects of network relationships according to the existing literature. Third, this study examines how inventions are commercialised and how firm performance is measured. Finally, the theoretical framework connects the commercialisation of inventions and network theory to form the basis of the empirical analysis.

The empirical analysis consists of two parts. The first part aims to describe the interorganisational networks of the analysed firms, and the second part aims to analyse the connection between network activity and firm performance to answer the research question. The first objective of the empirical portion is to determine whether network relationships have a positive connection with firm performance, and the second goal is to attempt to identify which factors have the most significant effects on performance. Furthermore, these results provide suggestions for policy makers who wish to develop more effective support methods.

1.3 Research methods

This study consists of two major parts: the theoretical framework and the empirical analysis. The theoretical framework is a literature review that explores three major topics. The first topic is entrepreneurial networks and network actors, the second topic is network evolution and dynamics, and the final topic is commercialisation and firm performance. All three topics are explored from the perspective of an emerging firm.

The empirical portion of this study is based on data that were collected through telephone interviews. The data set consists of 53 interviews and thus yielded a total of 53 separate data entries. The data are first analysed with descriptive statistics, and the hypotheses are tested with a multivariate regression analysis.

1.4 Structure of the study

The remainder of this study is structured as follows. The second chapter presents the theoretical framework, which provides an extensive review of the literature on entrepreneurial networks, network evolution and dynamics, and the commercialisation of inventions. The theoretical framework chapter summarises the theory that is used in this study and provides the foundation for the hypotheses that are presented in the third chapter.

The fourth chapter describes the data that were collected through the survey and from other external sources.

The fifth chapter explains the methodology that was used in this study and addresses the variables and model that were used in the regression analysis.

The sixth chapter presents the results of the analysis. This chapter first explores the descriptive statistics and then presents the regression results, followed by further exploration of the network activity; finally, the chapter analyses the robustness of the regressions.

The seventh chapter summarises the results, discusses the implications for managers and researchers, and analyses the limitations of the study.

2 Theoretical framework

The objective of this chapter is to construct the underlying theoretical framework based on the existing literature. In addition, this chapter presents the theory that is required to construct the hypotheses in the next chapter. This chapter is organised as follows: the first section discusses entrepreneurial networks, the second section explores network evolution and dynamics, and the final section combines network theory with the commercialisation of inventions.

2.1 Entrepreneurial networks

The history of network research within the field of entrepreneurship is only approximately 25 years old (Hoang and Antoncic, 2003). However, the network approach is a much older discipline that has been studied in the context of organisational research since the 1930s and is rooted in the concepts of sociology, anthropology, and role theory (Tichy et al., 1979, Nohria and Eccles, 1992, Parkhe et al., 2006). Because of the vast body of literature, this section discusses networks by narrowly focusing on the entrepreneurial aspects of network theory. Furthermore, the concepts that are presented in this section are essential for understanding the literature that is examined in the following sections. The main concepts that are addressed in this section are a) networks and how they are formed, b) key network actors, c) network brokering and management, and d) social capital.

Networks

The concept of networks is central for this study. Therefore, it is crucial to define the concept and discuss its characteristics. The definitions of a network vary, but in a highly cited review article, Hoang and Antoncic (2003) define networks as consisting of a set of actors (nodes) and a set of relationships (links) connecting these actors. The authors acknowledge that their definition is more general than most other definitions in the literature, but for this study, their definition is adequate because it is clear, and the article is widely cited. Therefore, this definition is used throughout the study.

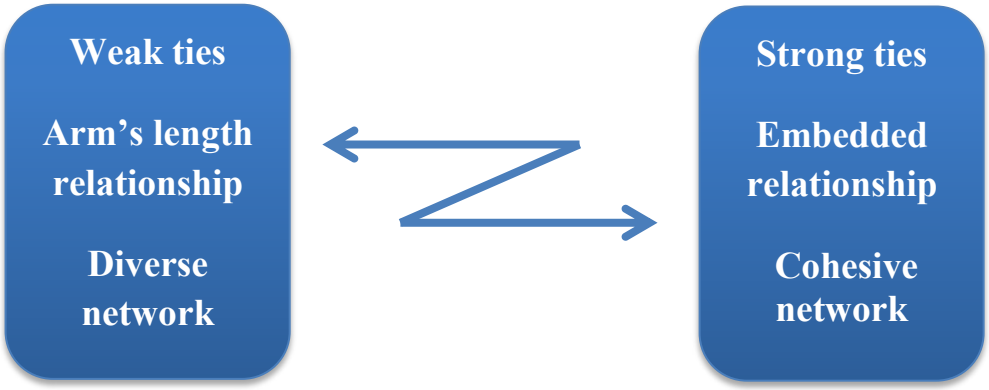
The links between network actors can be defined using two key concepts: weak and strong ties (Granovetter, 1973, Uzzi, 1997). Granovetter (1973) emphasises the importance of weak ties when connecting members of separate small groups. Hence, Granovetter argues that weak ties are more important distribution channels of new information than strong ties because distant actors have better access to alternate information sources than nearby actors. However, strong-tie relationships with close actors are primarily embedded (Granovetter, 1985). The concept of embeddedness indicates a business relationship that also has a personal side. In an embedded relationship, the trust between actors is pronounced.

Uzzi (1997) further develops the concept of embeddedness. He states that arm's-length ties are in complete contrast with embedded ties. Furthermore, an arm's-length relationship between actors is impersonal, and no personal relations exist between the actors. This concept is similar to weak ties. To clarify the general view, Figure 1 portrays the links between the concepts that are discussed in this paragraph and the previous paragraph.

Uzzi (1997) recognises that three comments of embedded relationships: 'trust, fine-grained information transfer, and joint problem-solving arrangements'. These three components control the expectations and behaviours of exchange actors. Embedded ties form primarily through third-party referral networks in which an actor who has embedded ties to two unconnected actors brings them together.

Uzzi (1997) emphasises that embedded ties have many positive effects on both sides, but negative effects also exist. In particular, ties that are over-embedded diminish the ability of actors to adapt. Therefore, the network of an actor should consist of both embedded and arm's-length ties to balance the positive and negative effects.

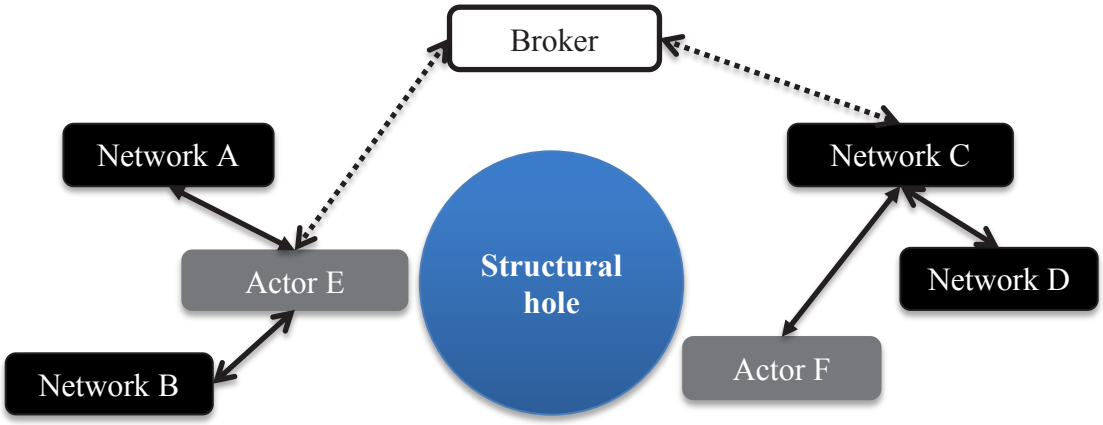
Figure 1 Summary of different types of ties



Moreover, networks can be divided into two groups based on their types of ties. Networks that primarily consist of arm's-length relations are diverse and lack social cohesion, whereas networks that consist of embedded relations are cohesive and facilitate repeated social and business interactions (Martinez and Aldrich, 2011). In addition, a cohesive network comprises members who are strongly and nearly exclusively connected to one another.

This study now proceeds to discuss the concept of structural holes (Burt, 1992) to broaden the focus to multiple networks. This concept is visualised in Figure 2. Burt (1992) argues that a structural hole exists when two networks are not connected and when information cannot be shared between these two networks. An actor who can act as an intermediary for these two networks is a broker. The role of a broker can be valuable, as an actor can broker the flow of information and, for instance, control which projects can access resources from opposite sides of the hole. The benefits of such information are access, timing, and referrals. Notably, the theory of structural holes is a generalised version of Granovetter's theory of weak ties (1973).

Figure 2 The concept of a structural hole



Thus far, this study has defined a network as comprising actors and the relationships that connect them. These relationships can be weak or strong, and an efficient network includes both types of ties. Furthermore, structural holes separate networks that are not connected. However, the question of why networks are formed remains unanswered and thus becomes the next discussion topic that precedes the exploration of the type of nodes in networks and the manner in which entrepreneurial firms benefit from diverse networks.

Network formation

According to Pittaway et al. (2004), there are two explanations for the formation of business networks. The first explanation focuses on a resource view according to which firms form network relationships to obtain access to technical or commercial resources (Ahuja, 2000, D'Cruz and Rugman, 1994, Staropoli, 1998). The second explanation focuses on a theory in which opportunities to form links tend to reflect prior relationships (Ahuja, 2000).

In addition to these two primary explanations, prior studies have found several other positive implications of networking (Pittaway et al., 2004). For instance, network relationships can provide emotional support for entrepreneurs who assume risks and thus increase the desires of entrepreneurs to continue conducting business (Hoang and Antoncic, 2003). Entrepreneurs can also use networks to gather information, ideas, or advice (Birley, 1985, Birley, 1987). More importantly, small business owners can gain access to research and development (R&D) outsourced by major firms; establish joint R&D ventures; and establish other relationships, such as marketing or manufacturing relationships (Rothwell, 1991, Rothwell and Dodgson, 1991).

Furthermore, Baum et al. (2000) claim that early inter-firm relationships are beneficial for the financial performance of start-ups because these relationships enable firms to overcome many potential hazards in the early stages of growth. Entrepreneurs can efficiently provide access to diverse information and capabilities by establishing the above-mentioned relationships (Teece, 1986). However, if an entrepreneur lacks social, technical, and commercial capital, then such a firm may experience problems when attempting to initiate the most interesting and beneficial partnerships, especially if the firm has no previous record (Ahuja, 2000).

In conclusion, networks are formed to gain access to resources and support. Furthermore, the creation of new relationships can reflect prior relationships. To gain access to various resources, a firm must form relationships with a diverse set of actors. Therefore, the next section addresses the most important network actors for entrepreneurial firms and discusses the advantages of diverse networks.

Network actors and firm innovation

In their study, Pittaway et al. (2004) argue that for an innovative firm that seeks both complex and radical innovative processes, a diverse set of network relationships and partners is beneficial because such a firm can then integrate different knowledge bases, behaviours, and habits of thought. Specifically, formal and informal information flow between partners can create unexpected novel combinations of knowledge. However, some firms may build innovation relationships with customers to lower the risk level that is associated with the overall relationship. Thus, customer knowledge assists firms in creating new innovations; however, the results are generally more incremental, and productivity gains are thus lower.

Moreover, Pittaway et al. (2004) state that network types and innovation types are directly connected. In addition, some findings indicate that low networking activity reflects as low innovation competence (Ritter and Gemünden, 2003, Pittaway et al., 2004). Ferrary and Granovetter (2009) emphasise that the economic success of a start-up is connected to both the entrepreneur or innovation and to the degree of embeddedness of the start-up in social networks. These networks provide financial resources, advice, partners, and experts (Ferrary and Granovetter, 2009). Understanding the key benefits of different actors is essential; thus, this study proceeds to discuss the actors within a network, beginning with suppliers.

The benefits of supplier integration are numerous, but only the most important benefits are discussed here. One benefit is that supplier integration leads to groundbreaking innovations when supplier integration specifically concerns innovation (Kaufmann and Tödtling, 2001, Romijn and Albu, 2002). Second, the supply relationship is recognised as one of the most important factors affecting innovation performance and productivity (Lincoln et al., 1998).

However, firms most often consult customers when initiating a network relationship for the purpose of innovation (Kaufmann and Tödtling, 2001). According to Ragatz et al. (1997), customers are the most important partners when firms seek incremental innovations. Furthermore, Conway (1995) finds that customers are essential for generating new ideas, and firms that are able to obtain critical information from customers are commercially more successful.

Suppliers and customers may be the two most important network partners for an entrepreneurial firm, but the following third parties are also essential despite their lower importance. The first third party that is explored in this study is science partners, such as universities and research organisations. Science partners are particularly important for a firm's research and development (R&D) department. These partners are vital for the transfer of scientific information to and from a firm, and they operate as intermediaries within networks (Bougrain and Haudeville, 2002). Network relationships with science partners are typically informal and personal (Bower and Keogh, 1996), and these relationships generally assist in expanding a firm's thinking beyond the normal business parameters (Liyanage, 1995).

However, science partners do not form a harmonious group. For instance, Ferrary et al. (2009) distinguish between universities and research laboratories. According to the authors, both types of organisations foster innovation, accumulate expertise, incubate start-ups, and socialise agents. Nevertheless, the authors state that universities also educate workers on the needs of other actors. In summary, science partners are important for firms that pursue radical innovation.

Other third parties include network partners and institutional mechanisms whose main activity is networking; although these parties have many forms and names, their goals are consistent. According to Pittaway et al. (2004), the most common forms of network partners and institutional mechanisms are incubators, clusters, and centres for co-operation. Other forms include science parks, industry networks, trade associations, and professional associations.

A further key actor group in a firm's early stage is financiers, who fulfil the financial needs of a start-up before it is able to self-finance its operations. Actors who belong to this group include venture capitalists and private investors. These actors differ slightly from the previous actor groups, as venture capital firms and venture capitalists (VCs) are typically interconnected and often form syndicates for investments (Bygrave, 1987). For instance, co-investments offer an information-sharing channel between VCs and thus enable venture capitalists to gather information pertaining to future technologies and trends. Furthermore, the networks that VCs create are beneficial for entrepreneurs, as these networks provide access to information and knowledge that is otherwise unavailable to a start-up (Florida and Kenney, 1988). Ferrary et al. (2009) report similar findings and argue that VCs have numerous other roles. For instance, VCs select which start-ups are financed and then embed and signal them. Signalling indicates that financing by a well-known VC simultaneously provides a positive signal that a financed firm has future potential and that the risk associated with operating with a start-up is lower. Therefore, at some level, financing decisions justify the existence of firms.

In addition to the actors who have been discussed in this study thus far, numerous other actors affect networks. However, this analysis limits the discussion to the key actors because the role of other actors is limited in the empirical portion. Some of the other actors include law firms, recruitment agencies, media, investment banks, competitors, consultants, industry networks, business clubs, and professional associations (Ferrary and Granovetter, 2009, Pittaway et al., 2004).

In summary, this sub-section has discussed the reasons that diverse networks are advantageous for entrepreneurial firms and examined the characteristics of key network actors, including suppliers, customers, science partners, network partners, and financiers. Moreover, entrepreneurs can form relationships with a diverse set of actors by connecting existing networks to one another. Therefore, this discussion proceeds to investigate network brokerage and the benefits that brokers provide.

Network brokerage

Burt (2005) suggests that brokers are actors who span structural holes between groups of people or organisations. Therefore, brokers have a critical role in improving information flow between groups (Kirkels and Duysters, 2010). Howells (2006) argues that in the context of small and medium-sized enterprise (SME) networks, the role of brokers is not limited to information transferring, gathering, or linking activities but that intermediaries provide a more holis-

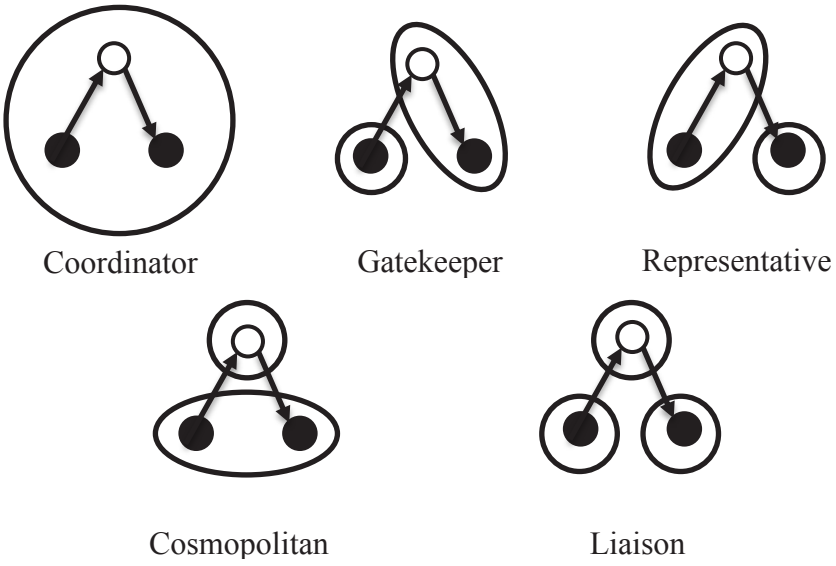
tic and varied role for clients in the innovation process than has generally been acknowledged. Furthermore, Snow et al. (1992) claim that managers should select their brokerage roles according to their objectives. However, the objective is not the only issue that affects the brokerage behaviour of managers; the personal goals and interests of managers also influence this behaviour (Gould and Fernandez, 1989, Täube, 2004). In summary, the structural environment, relations, information, and personal characteristics of an actor affect the goals and interests mentioned above (Burt, 2005, Kakati, 2003).

This discussion further examines various brokerage roles and how they differ. Figure 3 presents five types of brokerage (Kirkels and Duysters, 2010, Gould and Fernandez, 1989): coordinators, gatekeepers, representatives, cosmopolitans, and liaisons. First, a coordinator coordinates and enhances information flow between the members of the group to which he or she belongs, but no boundary spanning is apparent. A gatekeeper absorbs information from other groups and then transfers the information to the members of his or her own group. A representative purveys information from his or her group to other groups. A cosmopolitan acts as an intercessor who works in a group to which he does not belong. Finally, a liaison works as an intermediary between two groups to which he or she does not belong and thus enhances the flow of information between groups.

A focal actor can simultaneously operate in various roles among several different groups. Furthermore, Kirkels and Duysters (2010) state that knowing the types and roles that exist in a network is important; however, the lack of certain roles in a network describes the network even more aptly because this absence of roles reveals a significant amount information pertaining to the knowledge flows and transformations in the network.

There are various potential venues in which an entrepreneur can bridge ties and thereby act as a broker. Stam (2010) claims that industry events offer an important bridging opportunity for entrepreneurs and that some entrepreneurs bridge separate groups by attending events

Figure 3 Five types of brokerage (Kirkels and Duysters, 2010, Gould and Fernandez, 1989)



that are organised by these groups. These entrepreneurs gain an advantage by acting as a liaison among the separate groups. Stam (2010) also proposes that a bridging entrepreneur can become a community leader with privileged access to information and greater visibility among potential customers. Furthermore, compared with other events, participating events with few previously known participants offer better networking opportunities for the brokering of new linkages among numerous groups (Stam, 2010). This view is supported by Hoang and Antoncic (2003), who argue that entrepreneurs require more bridging ties compared with managers.

Moreover, Bergenholtz (2011) states that technology-intensive firms can benefit from cooperating with external actors. This cooperation, which in the example case consists of meeting scientists and other actors from unfamiliar and diverse technical fields, provides access to otherwise unavailable information, which is important and valuable for firms. However, the co-operational model is expensive and requires many working hours. The focus of this cooperation is primarily on information brokering between actors and on marketing a firm's expertise. In addition, Bergenholtz (2011) recognises the benefits and threats of information sharing particularly in the form of spill-overs. He states that when only the focal actor has the capacity to broker information and when the other actors have diverse backgrounds, the risk for 'unwanted knowledge spill-over' is low. This condition is especially applicable when a relationship is based on a weak tie. In this case, the other actors are not likely to be interrelated. Therefore, the actors are in separate social networks, and the focal actor can broker information between these networks (Gilsing et al., 2008). However, the exchange of complex information is more difficult than when relationships are based on strong ties (Bergenholtz, 2011). Furthermore, Bergenholtz (2011) recognises that the nature of a certain technology also affects the outcome of the process. A firm that utilises a niche technology has a difficult task in creating a network based on weak ties compared with a firm that has a broader technology background.

In conclusion, the key activity of a broker is to provide a channel for information flow between network actors. A broker benefits from this position because he or she can obtain exclusive access to information and thus constrain the access of other actors. Moreover, if network relationships are based on weak ties, then the threat of unwanted spill-overs is low. However, entrepreneurs must know how to manage these relationships. Thus, the discussion proceeds to examine network management.

Network management

Network management is a key aspect of networking, and the types of network management and governance affect the types of network ties (Bolton et al., 1994). When a relationship between actors evolves from a weak tie to a strong tie over time, the actors within this relationship eventually trust one another, and the relationship provides an effective channel for information flow (Coles et al., 2003, Larson, 1991). Uzzi (1997) finds that trust is especially likely to develop when both sides devote additional effort (typically voluntary effort) to a relationship. This additional effort is typically described as 'favours', as official reciprocity (e.g., contracts) cannot be observed. In addition, Uzzi (1997) alleges that a trust-managed relationship offers access to otherwise unavailable resources that can increase competitiveness. Information flow that is based on trust has been shown to be an integral aspect of a strong, long-term inter-firm relationship (Lipparini and Sobrero, 1994, Pittaway et al., 2004). Reliance on strict contracts rather than trust between actors has been shown to depend on the culture and the institutional context in which firms operate (Bolton et al., 1994, Nooteboom, 2000).

In their study, Provan and Kenis (2008) propose a typology of three distinct governance mechanisms for relationships between organisations: shared governance, a lead organisation-governed mechanism, and a system that is governed by a network administrative organisation (NAO). The shared governance method is based on an assumption that the organisations in a network manage the operation of the network by making both strategic and operational decisions together; therefore, no formalised governance body exists. Lead organisation-governed networks typically have one larger or more powerful firm that operates as the lead or hub firm. All of the firms in such a network share a common purpose, but only the lead firm may have the resources or legitimacy that is required to serve in the lead role in the network. NAO-governed networks are comparable to lead organisation-governed networks, as both types of networks are managed by one central organisation. In contrast with lead organisation governance, the controlling organisation in NAO-governed networks has only a pure governance role. Additionally, Provan et al. (2007) observe that the NAO model is common in some European countries (e.g., Germany) because this type of network is believed to simulate interactions between the public sector and the private sector in clusters or networks.

In their review of networks and innovation, Pittaway et al. (2004) conclude that firms have the competence to manage their networks, but the level of competence varies widely across firms. Additionally, the extent to which firms have access to new opportunities is connected to their existing networks and participation in those networks (Powell et al., 1996).

In conclusion, trust is one of the key network management methods. The network management method is both culturally and institutionally dependable. For example, other network management methods include shared, lead organisation, and NAO governance. However, before discussing network evolution and dynamics, this study briefly examines the concept of social capital because it is closely related to the concept of networks (Adler and Kwon, 2002).

Social capital

According to Adler and Kwon (2002), the definition of social capital is as follows: 'Social capital is the goodwill available to individuals or groups. Its source lies in the structure and content of the actor's social relations. Its effects flow from the information, influence, and solidarity it makes available to the actor'. Furthermore, the concept of social capital has been investigated extensively in the literature; hence, a thorough examination of this concept is beyond the scope of this study. Therefore, in this study, the concept of social capital is posited as being similar to the topics that are covered, and the study addresses several benefits and risks that are associated with this type of capital.

Furthermore, Adler and Kwon (2002) claim that three individual benefits arise from social capital: information, power, and solidarity. As Coleman (1988) explains, the benefits of power may include the accumulation of social capital, which can be observed as increased social power and influence over other actors. In addition, Adler and Kwon (2002) state that solidarity, which is associated with the goodwill effect of social capital, reduces the need for formal controls because solidarity is connected with strong social norms and beliefs.

In summary, this section has discussed the key concepts of networks for entrepreneurial firms, and this discussion now proceeds to address the evolution of such networks.

2.2 Network evolution and dynamics

The main objective of this section is to examine how a network evolves over time by exploring the key aspects of network evolution and dynamics. Furthermore, the analyses in this section and the following section create the basis for generating the hypotheses in Chapter 3. The main concepts that are addressed in this section are a) a firm's life cycle and network evolution, b) the evolution of embedded ties, c) the evolution of innovation networks, d) the evolution of venture networks, and d) the evolution and dynamics of international ventures.

Firm life cycle and network evolution

Both strategy and entrepreneurship research divide organisational life cycles into several stages: emergence, early growth, later growth, maturity and often death (Hite and Hesterly, 2001, Gartner and Brush, 1999, Kazanjian and Drazin, 1989). However, Hite and Hesterly (2001) note that the above model is limited and that it is difficult to define the stage in which a firm is currently operating. Moreover, a change in stage is both a change that occurs over time and a proxy for numerous other strategic changes, such as goals, asset stocks, resource needs, and resource acquisition changes (Hite and Hesterly, 2001, Reese and Aldrich, 1995). Hite and Hesterly (2001) claim that firms in early stages encounter three distinct resource acquisition challenges, including availability, accessibility, and uncertainty, which strategically vary through emergence and early growth. In addition, the authors argue that these three issues are important originators of network evolution.

Moreover, Hite and Hesterly (2001) propose that during the emergence of a firm, entrepreneurs form their networks based on their existing social networks. A firm's network evolves during the emergence stage, and entrepreneurs form interpersonal network ties through routines and procedures. These ties may become interorganisational by providing channels for information and resource exchange between organisational entities. Furthermore, Hite and Hesterly (2001) propose that three changes occur simultaneously in a firm's network when the firm undergoes a stage change. These three changes represent a movement from an identity-based network to a more calculative network.

First, during a stage change, the proportion of embedded ties within a firm's network decreases because new relationships are more based on instrumental and economic exchange than on social commitments and relationships. Second, as network cohesion decreases during a change of stage, the number of structural holes that a firm must bridge increases. Third, during the emergence stage, a path-dependent process dominates the evolution of networks, but during a change in early growth, network management becomes more intentionally managed. Moreover, Hite and Hesterly (2001) argue that the evolution of networks that is proposed above is a response to a change in the availability, accessibility, and uncertainty of resources during a stage change in conjunction with changes in the needs of a firm. Therefore, the authors conclude that the coevolution of a firm is interconnected with its resource needs, challenges, and networks.

In conclusion, the life cycle of a firm consists of several stages. These stages are not clearly defined, and a firm may bypass a stage. Moreover, a change in stage is a proxy for numerous strategic changes that a firm experiences. As a firm evolves and progresses to various stages, its network and resource needs also evolve. Subsequently, this study proceeds to discuss how individual network ties evolve with special emphasis on embedded ties.

The evolution of embedded ties

The majority of the relationships of an early-stage firm are grounded in former personal relationships that are often based on embedded ties (Hite, 2005). These relationships with different actors evolve recursively over time to become fully relationally embedded and thus offer access to trust, which is the key governance mechanism for contracting (Hite, 2005, Dyer and Singh, 1998, Uzzi, 1997). Furthermore, entrepreneurs have few methods of managing the evolutionary path but can have a greater influence in the social leveraging process (Hite, 2005).

Hite (2005) defines social leveraging processes as enabling existing social network ties to develop other social components, such as personal relationships, social capital, and dyadic interactions, with existing components. The active management of the social leveraging process can affect the type and extent of embeddedness. Furthermore, Hite (2005) argues that embeddedness may influence the possible level of trust in relationships. However, an early-stage firm must find a balance between the positive and adverse effects of over-embeddedness. These effects can emerge, for instance, as easier access to resources or as unfavourable decisions.

Moreover, Hite (2005) argues that partially embedded network ties require other modes of governance before trust can be fully developed. These governance methods must be observed and changed during the evolution of a relationship. However, governance modes interact with the evolution of embedded ties, and this interaction complicates the entire process. According to Hite (2005), some relationally embedded ties do not develop into fully embedded ties, and some ties even begin to devalue as their relevance decreases.

Overall, embedded ties are typically grounded in the former personal ties of entrepreneurs. In addition, the governance method of embedded relationships depends on the level of trust. Entrepreneurs can influence the social leveraging process more than the evolutionary path, which is less manageable. To better understand the evolutionary path, this study broadens the discussion to the network level. The first topic of discussion is the evolution of innovation networks.

The evolution of innovation networks

Most earlier studies have researched the evolution of innovation networks in the context of the biotechnology industry (see, e.g., Powell et al. (2005), Gay and Dousset (2005)). In their article, Gay and Dousset (2005) claim that it is essential to understand how networks evolve and the dynamics behind this evolution. Moreover, the authors argue that the most connected and central firms in a network hold the patents that are perceived as the key intellectual property (IP) in a certain sector. This fact and the examination of network structures demonstrate the strong connection between innovation and the emergence of a network structure. Furthermore, Gay and Dousset (2005) extend the analysis by claiming that the most central firms form hubs and that these hubs are interconnected. These connections evolve primarily based on technologies, and information appears to flow primarily from central actors to actors with lesser centrality scores. However, linkages to central hubs are limited by technological evolution over time, and new technologies shape the overall evolution of such networks.

Additionally, Gay and Dousset (2005) emphasise that although hubs hold the power because they own the key IP, the overall diffusion of knowledge from the central players is rapid. In addition, when discussing preferential attachments, Gay and Dousset (2005) argue that the hy-

pothesis of the 'fitter-get-richer' (Bianconi and Barabási, 2001) is more justified than the hypothesis of the 'rich-get-richer' (Barabási and Albert, 1999). Gay and Dousset (2005) define fitter firms as firms with state-of-the-art technology. The authors argue that young nodes can accrue linkages rapidly if they have a high level of fitness with potential partners and if their centrality increases simultaneously. Nodes with different fitness values also evolve and compete for links over time. Moreover, the alliance formation rate of hubs changes through different technological stages that correspond to different network structures and technological capabilities. Finally, Gay and Dousset (2005) argue that network structures and growth stages are interconnected and that the former changes according to the latter. In addition, there is a link between stage changes and radical innovation. The authors also propose that information diffusion and incremental innovation are processes that follow radical innovation.

In their study of alliances, Baum et al. (2010) claim that firms usually ally with a restricted set of actors because the information value of ties elevates partnerships with past partners, and new partnerships are created based on referrals of past partners who are in a lucrative position. However, bridging the parts of a network that is separated by structural holes offers a valuable opportunity for firms to utilise the vision, brokering, and control of resources that are attained by connecting these networks.

In conclusion, in innovation networks, the transfer of knowledge in different forms is one of the key forces behind the formation of network relationships. Furthermore, innovation networks evolve in connection with the evolution of technology as needs change and as knowledge is diffused rapidly through the networks. After discussing the evolution of innovation networks, this study elaborates on the evolution of venture networks. Moreover, the study aims to explore the differences between successful and less successful firms.

The evolution of venture networks

The evolution of venture networks varies. However, Jack et al. (2008) note that the two successful firms that are examined in their case study repeat the growth stage process multiple times during the six-year observation period. Although all three entrepreneurs who are observed in the study recognised the need to expand their networks, only the two successful entrepreneurs networked actively in their respective industries. In contrast with the successful entrepreneurs, the less successful entrepreneur networked only through local professional and commercial networks.

Moreover, Jack et al. (2008) argue that the entrepreneurs' meetings and connections with new individuals created a pool of weak-tie relationships whose characteristics were known. The authors explain this process as creating a pool of potential strong-tie relationships that await formation. In addition, Jack et al. (2008) propose several positive effects that strong-tie relationships provide to successful entrepreneurs. The entrepreneurs use discussions with their strong ties to ascertain their visions of the future and to broker introductions to key potential customers. Furthermore, entrepreneurs can deepen their senior relationships, which can even develop into friendships over time.

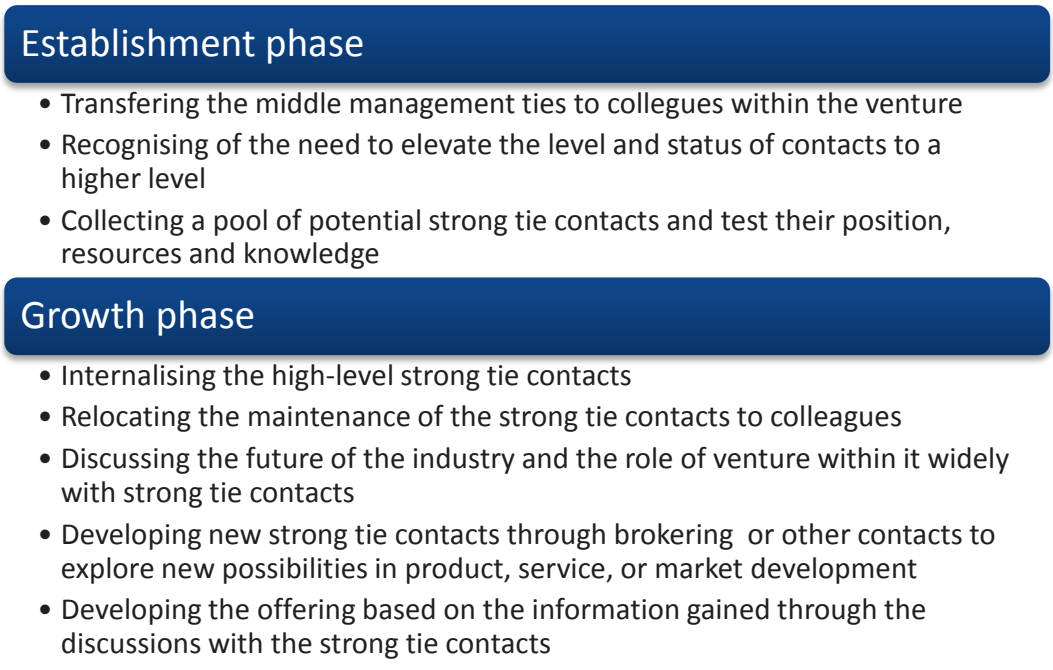
Moreover, these senior relationships may be required to take business relationships to the next level, at which such relationships extend beyond the trading of goods (e.g., the development of new products or services). One benefit of this process is that the early broadening of a net-

work improves future flexibility and hinders the negative effects of an embedded network, especially when changes are required (Jack et al., 2008, Kim and Aldrich, 2005). Furthermore, an economic interaction can occur only after a social interaction has occurred (Jack et al., 2008). However, this result is not consistent with the findings of Hite (2005), who states that economic interactions occur prior to the development of social ties. A possible explanation for these different results may be differences in industries, business logistics, or locations, such as the Scottish oil industry in the research of Jack et al. (2008) and the computer industry in the United States in the work of Hite (2005). Figure 4 presents the key processes of a venture in its establishment and growth stages (Jack et al., 2008).

Studying the dynamics of evolution in entrepreneurial networks, Jack et al. (2008) claim that the environmental learning of entrepreneurs and their networks are interconnected. For instance, entrepreneurs may discuss a 'fact' that they have learned from a source within their strong-tie connections and form their own opinion and evaluate the effects only after the discussion process. Furthermore, the authors argue that social interactions 'construct' the market and that entrepreneurs use strong ties to exploit the experiences of partners, to learn from these experiences, and to shape the network experience to change the strategic direction of the ventures. Finally, Jack et al. (2008) argue that individuals who are better connected have access to more relevant knowledge.

In summary, networks of ventures evolve over time. Furthermore, relationships among ventures also evolve, and new weak relationships created by ventures can develop into strong relationships. These strong ties create channels for information and resource sharing. Furthermore, these channels offer entrepreneurs opportunities for environmental learning. To broaden the context of this sub-section from a local to a more international level, the following discussion examines international new ventures (INVs).

Figure 4 Key processes in the establishment and growth stages (Jack et al., 2008)



The evolution and dynamics of international new ventures

For many ventures, the local market is not sufficient. Therefore, this study proceeds to discuss international new ventures (INVs). In her study, Coviello (2006) distinguishes INVs as ventures with an early focus on global activities and internationalisation, and she argues that INVs use networks to facilitate rapid internationalisation. Coviello (2006) divides the evolution of firm networks into three distinct stages: emergence, commercialisation, and sales growth (Kazanjian and Drazin, 1989). In each stage, the structure of the network was measured in range, density, and closeness and betweenness centrality for the three firms. First, Coviello (2006) reports that as the firms grow, the range of INV networks increases, and their density decreases. Second, constraints on the ventures decrease as the non-redundant aspects of the network increase. Third, the firms have high closeness values throughout each stage, whereas their betweenness values, which measure the degree to which a firm is positioned between other actors, increase in each stage. All three observations have an increasing effect on social capital. Observing the network evolution of young INVs, Coviello (2006) remarks that this network is both path-dependent and intentionally manageable in each of the three stages.

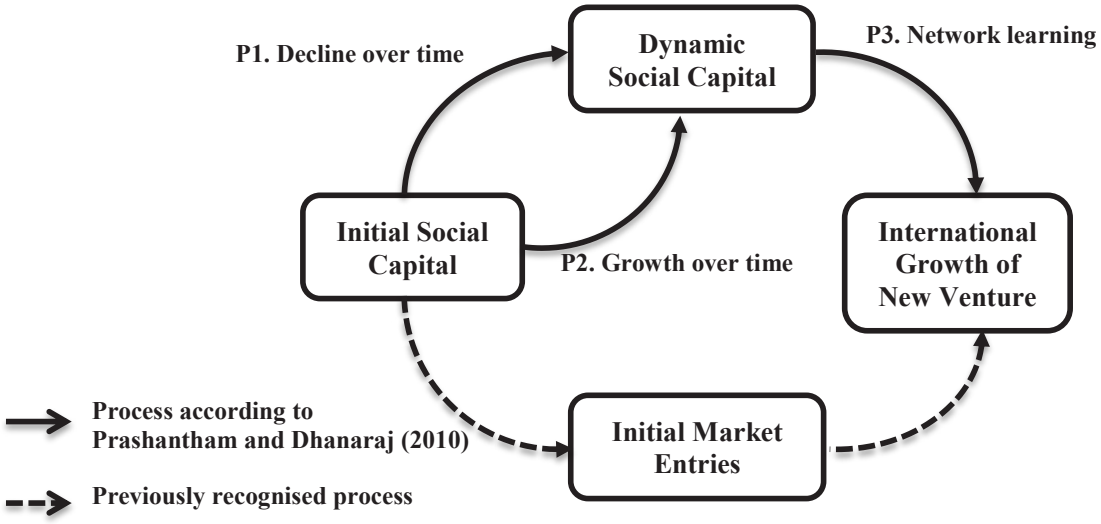
In addition, Coviello (2006) analyses how the network interactions changed during the three stages. The common factor for each of the three firms is that they internationalised through network ties that were generated during or even prior to the first stage, and these ties are more economic than social in nature. It was remarkable how important the early ties are for internationalisation and how third parties act as catalysts in all ties. However, although third-party referrals are common in all three stages, the reputation of the firms remains at a low level throughout each of the stages (Coviello, 2006).

In another INV study, Prashantham and Dhaharanaj (2010) claim that entrepreneurs dynamically produce and distribute social capital over time. The authors also find that three separate processes affect the depreciation of social capital: tie decay, tie obsolescence, and tie utility life cycle. Tie decay refers to the diminishing use of a tie over time, which decreases the usefulness of network relationships. Tie obsolescence occurs when a tie becomes obsolete because the usefulness of a relationship is situation dependent (e.g., a network connection has departed from its previous position). Finally, a tie utility life cycle refers to a phenomenon in which a contact cannot provide, for instance, new direct business relationships after a certain period. In conclusion, these three processes affect the decline of social capital over time.

Studying the growth of social capital, Prashantham and Dhaharanaj (2010) find that successful ventures (as measured in revenue growth) recognise the need to expand their social networks and act accordingly by searching for new potential network actors and by deepening their networks both overseas and in their home markets. In particular, successful ventures extend beyond the known network relationships and attempt to benefit from previous business contacts. Compared with less successful ventures, successful ventures utilise more proactive and cost-effective measures to access new international markets. These measures include government-subsidised trade missions abroad, emails and telephone calls, or relationships that are formed with local representatives of foreign trade bodies. Prashantham and Dhanaraj (2010) conclude that successful firms utilise more inventive methods when attempting to expand their social capital during the internationalisation process.

Additionally, Prashantham and Dhaharanaj (2010) argue that social capital provides a network learning process and that firms that are able to exploit the process have higher growth rates. Furthermore, according to the conceptual proposals (Nahapiet and Ghoshal, 1998) and empirical evidence in various studies, social capital facilitates the creation and acquisition of new information and knowledge (Yli-Renko et al., 2001, Wu, 2008, Nielsen and Nielsen, 2009). In their study, Prashantham and Dhaharanaj (2010) argue that successful ventures are better able to learn from their strong and weak ties about new international markets and especially how to provide better service for their customers in a certain market. Figure 5 presents the processes that are discussed in this sub-section.

Figure 5 A model of how social capital impacts on the internationalisation of a new venture (Prashantham and Dhanaraj, 2010)



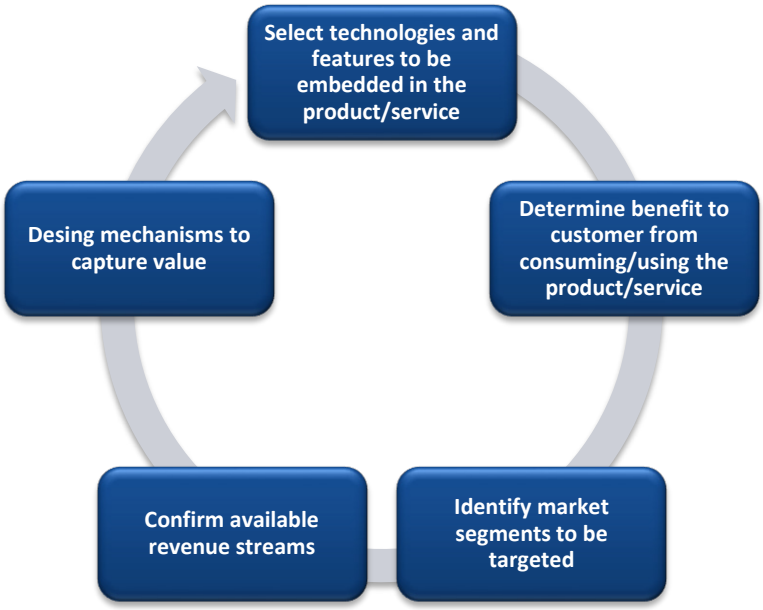
In conclusion, the network of an INV evolves in three stages. Furthermore, there are three different processes that increase the social capital of such ventures in each of the three stages. However, the value of existing relationships in a network depreciates over time because of three separate processes; therefore, it is essential to form new network relationships. This chapter has thus far primarily discussed networks of entrepreneurial firms and how these networks evolve. The following section aims to connect the above discussion to the concept of commercialisation.

2.3 The commercialisation of an invention

The commercialisation of an invention is a multistep process, and a business model is an essential part of this process. A business model expresses the logic of how a firm creates and delivers value to customers. In addition, a business model describes the logic of the organisational and financial architecture of a firm (Teece, 2010, Chesbrough and Rosenbloom, 2002). Teece (2010) argues that a business strategy in which strategists define how a firm creates competitive advantages and mechanisms with which to generate high profits is more theoreti-

cally abstract than a more generic theory of a business model. Additionally, a key task following the development of a viable model is to ensure that the model is differentiated and that it continues to undergo further development. Figure 6 presents a model that explains the design of a business model and describes the continuous nature of the model-creation process.

Figure 6 The phases of business model design (Teece, 2010)

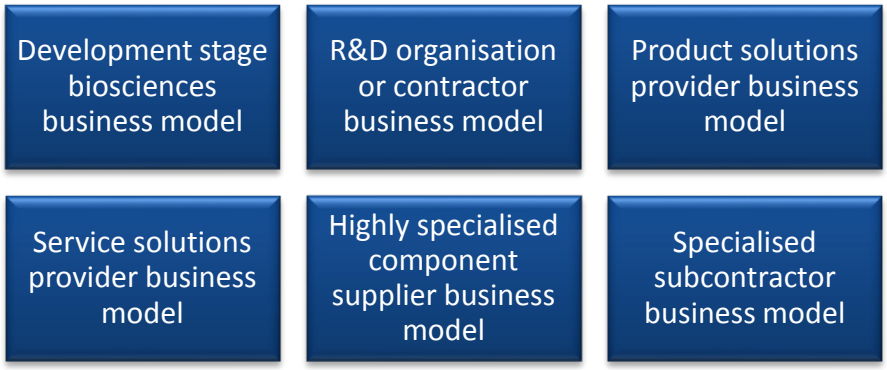


The creation of a plausible and functional business model is especially important in commercialising an invention. Teece (2010) states that it is essential for every venture to form a clearly defined business plan that establishes a 'go-to market' and 'value-capturing' strategies. Creating a business model that is compatible with the technology strategy is imperative for commercial success and for the creation of sustainable competitive advantages. Furthermore, in the creation of a business model, it is essential to have access to both information and intelligence from customers, competitors, and suppliers in addition to creativity and insights (Teece, 2010). Moreover, Teece (2010) proposes that designing a process of delivering value to customers is as significant as designing a value-capturing mechanism. In addition, Teece (2010) argues that a model without well-designed value-delivering or value-capturing processes is not sustainable.

Two extreme business models are recognised for capturing the value from an innovation: an integrated model and a licensing model (Teece, 2010). In the integrated model, an innovator firm is responsible for the process from design to distribution. The integrated model is remarkable in that the innovator both innovates and embeds the innovation into a product or service. However, in the licensing model, an innovating firm is responsible only for the creation of an innovation or invention, and a licensee is responsible for commercialisation. In the first model, a key requirement for success is to possess the assets that are required for product design, manufacturing, and distribution. In the second model, a key requirement for sustainability is strong intellectual rights that protect the innovator from the licensee, who could at-

tempt to capture the value. However, most business models are hybrids of these two models. The development of sustainable hybrid models is not easier than that of the extreme models. Nevertheless, both models require the appropriate skills (Teece, 2007, Teece, 2010). In particular, the licensing model is similar to the concept of open innovation in which firms license innovations to and from one another (Chesbrough, 2006, Chesbrough, 2003). Compared with the highly theoretical models that were provided by Teece (2010), Libaers et al. (2010) propose six different business models for technology firms concentrated on innovation. These models are presented in Figure 7.

Figure 7 Business models for innovative firms (Libaers et al., 2010)



The resulting business models are not unchangeable. After a firm understands its customer needs, determines what its customers want, and designs a business model that satisfies the needs of the firm more aptly than previous models, the managers of the firm can be considered business pioneers. Nevertheless, this situation is only temporary because the competitive landscape is continually shifting. Thus, a firm may need to revise or even abandon its current business model regardless of the previous success of the model. Similar to the initial business model proposals at the beginning stages of the life cycle, the model must be developed through learning and adjustments (Teece, 2010).

The commercialisations of research and technology inventions and innovations are key processes in high-technology firms. Markman et al. (2008) divide these processes into three categories: internal, quasi-internal, and external approaches. The internal approach can be divided into two groups based on the organisation type: firms and universities. In universities, a technology transfer office (TTO) is usually responsible for serving as a bridging actor and boundary spanner between academic scientists ('suppliers') and entrepreneurs/ventures ('customers'). The challenges of a TTO include the norms, standards, and values of scientists and entrepreneurs/ventures that are distinctly different.

According to Markman et al. (2008), quasi-internal approaches are also used by universities and firms to accelerate the commercialisation of innovations. A key operator in the quasi-internal approach is a business incubator, who offers business support, resources, and services for both entrepreneurs and ventures. Furthermore, a university incubator should choose an approach that endorses other aspects of the university's innovation system (Phan and Siegel, 2006, Clarysse et al., 2005). Figure 8 summarises the four main objectives of a business incu-

Figure 8 The four main objectives of incubators (Markman et al., 2008)

bator. Keil et al. (2008) imply that both social and network factors have key roles in the commercialisation of innovation; this implication is consistent with previous studies of university environments (e.g., Zucker and Darby (1996).

The third mode of research and technology commercialisation is an externalisation approach, which includes several methods, such as university research parks, regional clusters, academic spin-offs and start-ups, licensing, contract research and consultancy, joint venture spin-offs, alliances, collaborations, and open science and innovation (Markman et al., 2008).

In conclusion, this section has described the importance of selecting an appropriate business model, which must be redesigned over time. Redesigning is essential in the ever-changing competitive landscape. Moreover, although business models differ, networks assist firms in creating effective relationships with partners. This chapter has explored a vast body of literature and has simultaneously formed the theoretical framework for this study. The following chapter summarises the analysis that is presented in this chapter and forms the hypotheses that will be investigated in the empirical part of this study.

3 Hypotheses

The overall conclusion of the literature review suggests that network relationships are beneficial and vital for firms, especially for entrepreneurial firms that aim to grow and internationalise. Next, the theory is summarised before the hypotheses are formed.

A network is defined as ties that connect a set of actors (Hoang and Antoncic, 2003). These ties can be weak or strong depending on the type of relationship (Granovetter, 1973, Uzzi, 1997). The concept of strong ties is closely related to the concept of an embedded relationship, which comprises three key characteristics: trust, information transfer, and joint problem solving (Uzzi, 1997). In addition, the structure and content of social relationships are also sources of social capital, which is manifested in the goodwill that is available to parties involved in a relationship (Adler and Kwon, 2002). Goodwill is expressed in three forms: information, influence, and solidarity, which are advantageous for network actors (Adler and Kwon, 2002). The benefits of social capital and embedded relationships are closely related and are valuable and necessary for firms. However, both concepts also pose disadvantages if they are used or relied on excessively. A firm must find a balance between positive and adverse effects (Hite, 2005).

Specifically, trust between actors is recognised as initiating the flow of information between actors (Coles et al., 2003, Larson, 1991), and trust is regarded as a substitute for formal contracts and thus offers access to otherwise unavailable resources (Uzzi, 1997). However, a trust-based relationship that is associated with strong ties and embedded relationships is not always

the most beneficial for a firm, as Hoang and Antoncic (2003) claim that managers require more strong ties compared with entrepreneurs, who need and benefit from bridging ties. In general, brokering can provide access to information and resources that are otherwise unavailable (Kirkels and Duysters, 2010).

This chapter has described the basics of networks. The analysis now shifts to an examination of the evolution of networks. The network is not stable and evolves over time in a manner that is similar to how a focal actor evolves. Kazanjian (1989) describes the following three first stages of a firm: emergence, early growth, and later growth. Despite the weaknesses of the stage model (e.g., Levie and Lichtenstein (2010)), it illustrates reasonably well how strategic changes occur when a stage is changed or within a stage (Reese and Aldrich, 1995). The evolution of a network may respond to changes in the availability, accessibility, and uncertainty of resources during a stage change (Hite and Hesterly, 2001). The above information addresses the importance of networks when a firm is attempting to adapt to a change of stage.

This chapter has previously claimed that information and resource access are the key benefits of networks. According to Gay and Dousset (2005), the flow of information in innovation networks from focal actors who own key intellectual property diffuses knowledge to other actors in such networks. Furthermore, firms with state-of-the-art technology have greater potential to connect within such a network. Ultimately, even if firms do not possess state-of-the-art technology, network connections provide knowledge inflow that such firms can utilise.

Prior studies have recognised processes that are common to successful firms. For instance, in a case study, successful entrepreneurs networked actively in their respective industries and deepened relationships with several ties with whom personal friendships developed over time (Jack et al., 2008). The networks were also used in the study for environmental learning and to gather experiences from others; therefore, the relationships provided enhanced access to relevant knowledge and resources that were required for a business to operate and evolve (Jack et al., 2008). In addition, Jack et al. (2008) argue that a social relationship must be formed before economic transactions can occur. A focal actor capitalises network relationships efficiently when they are exploited to learn how to further develop the firm or to create new business opportunities, in contrast with efforts to generate direct business opportunities or contacts (Prashantham and Dhanaraj, 2010).

Furthermore, the social capital of an entrepreneur depreciates because of three distinct processes: tie decay, tie obsolescence, and tie utility life cycle (Prashantham and Dhanaraj, 2010). The depreciation of social capital emphasises the need to create new social capital, which can be attained by creating new ties and relationships. The aim of a firm should be to generate new social capital or at least to maintain the current level of social capital.

A theoretical application is given to further explain how a network evolves. During the early stages of the life cycle, the network of an international new venture grows in range but decreases in density. This process reflects the creation of new connections that are weaker than the original connections. If the density decreases excessively, then a network may become excessively sparse and thus difficult to manage. Therefore, a venture must balance the size and density of a network in the early stages of Kazanjian's model (1989). However, a larger number of connections may provide better information, resource access and potential for control (Coviello, 2006).

This chapter has addressed network theory. The chapter now proceeds to discuss the commercialisation of inventions. Specifically, in the commercialisation of an invention, the creation of a plausible and functional business model is essential for a new firm (Teece, 2010). However, such models must be continuously developed and sometimes even redesigned. Furthermore, access to information is extremely significant during the development and redesign processes (Teece, 2010).

Teece (2010) captures the need for information in the following statement: 'In short, one needs to distil fundamental truths about customer desires, customer assessments, the nature and likely future behaviour of costs, and the capabilities of competitors when designing a commercially viable business model.' The need for information that can be provided by a network connects commercialisation theory with the network theory that was presented earlier in this chapter.

In conclusion, this chapter has addressed the importance and benefits of networks (see, e.g., Jack et al. (2008), Gay and Dousset (2005), Coviello (2006), and Prashantham and Dhanaraj (2010)). Furthermore, based on the above discussion, the following question emerges: 'Does network activity have a positive effect on firm performance?' The expected positive connection between network activity and firm performance can be defined as follows.

Hypothesis 1:
Network activity has a positive connection with the performance of a firm.

The second aspect of networks that Coviello (2006) and Prashantham and Dhanaraj (2010) specifically emphasise is the importance of networking when a firm internationalises its activities. Moreover, Wright et al. (2007) imply that entrepreneurs must establish network connections to secure access to appropriate resources, knowledge, and learning to form 'a positive platform for internationalisation'. In addition, Andersson and Wictor (2003) suggest that entrepreneurial networks are essential assets for ventures that are attempting to internationalise their operations. Furthermore, Ojala (2009) proposes that knowledge-intensive SMEs form new network relationships or utilise existing relationships when extending their market presence to new distant markets. In conclusion, the above discussion suggests a positive connection between activity in entrepreneurial networks and internationalisation. Hence, the expected positive connection between network activity and a firm's internationalisation can be stated as follows.

Hypothesis 2:
Network activity has a positive connection with the internationalisation of a firm.

However, in these hypotheses, the concept of network activity does not describe how network activity changes. To address this issue, this section further discusses network activity. In her study, Coviello (2006) argues that embedded ties that are formed in the early stages of the life cycle have an important role when a focal actor is internationalising its operations even if the process occurs during later stages. Moreover, Prashantham and Dhanaraj (2010) argue that the depreciation of social capital is a natural part of evolution and that entrepreneurs must create new substituting relationships. However, Jack et al. (2008) found that entrepreneurs who were active with their existing strong ties also actively created new weak ties, and some of these weak ties were nurtured to become active strong ties.

The above discussion highlights the question of whether the concept of network activity should be divided into two separate factors: 1) consistently high network activity and 2) increasingly high network activity. Consistently high network activity describes long-term embedded relationships, and increasingly high network activity describes the importance of the creation of new relationships and ties. The first factor describes a situation in which network activity does not substantially evolve. By contrast, the second factor describes a process in which the network size increases as the needs of the focal actor evolve, and the increase counteracts decreases in social capital.

After network activity is divided into two separate factors, the former hypotheses can be revised as follows:

Hypothesis 1a:
Consistently high activity with network actors has a positive connection with the growth rate of a firm.

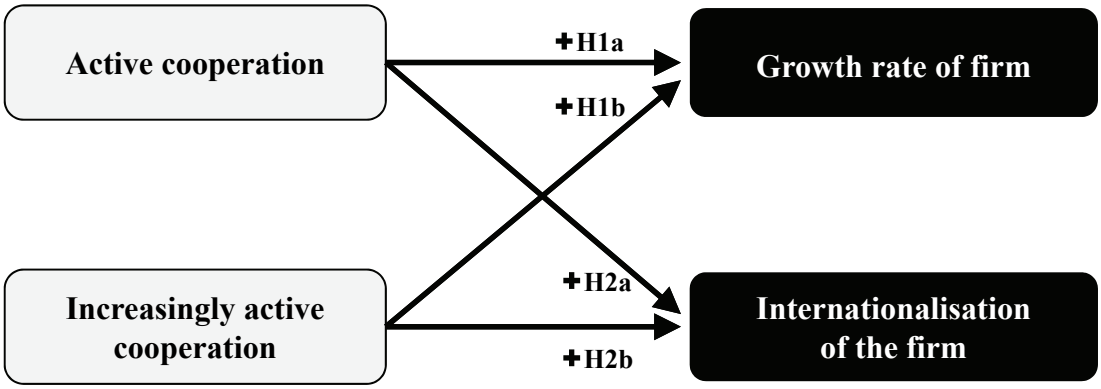
Hypothesis 1b:
Increasingly high activity with network actors has a positive connection with the growth rate of a firm.

Hypothesis 2a:
Consistently high activity with network actors has a positive connection with the internationalisation of a firm.

Hypothesis 2b:
Increasingly high activity with network actors has a positive connection with the internationalisation of a firm.

The hypotheses that are addressed above and the researched connections are portrayed in Figure 9.

Figure 9 The hypotheses and proposed connections



4 Data

This chapter first discusses how the data were collected and how the survey was conducted. The final part of this chapter describes and explains how the measures that are utilised later in this study were created.

4.1 Sample

The firms in the sample were selected according to four criteria. The first criterion was that the firms were Finnish or Finnish subsidiaries of foreign firms. The second criterion was that the firms operate in the energy, environmental, or nanotechnology sectors. Energy technologies were further narrowed to consist of only renewable energy technologies. The third criterion was that the firms had a maximum of 250 employees in 2007. The fourth and final criterion was that the business model of the firms must consist of activities beyond manufacturing activities; in particular, R&D activities must be emphasised.

The first and second criteria were created based on the scope of the study, and the criteria strictly narrowed the potential number of firms that could be interviewed. The first criterion also included firms that were owned by a foreign parent because many originally Finnish-owned technology firms have recently been sold to foreign firms. However, only subsidiaries that were observed to operate independently were included in this study. The third criterion was established to delimit larger firms from the study. Thus, the aim of the third criterion was to guarantee that the studied firms were comparable, as larger firms might operate in technology sectors other than those defined in the second criterion, which could bias the results. The fourth criterion was aimed to exclude less technologically intensive firms from the study. A review of the technological intensity of the firms was performed based on material from the firm websites, other public data sources, and newspapers (e.g., Kauppalehti). The scope of the study justifies these exclusions. A total of 123 firms were recognised as fulfilling the criteria described above.

As discussed in the previous section, the sample firms were identified from various sources. The most important sources were previous public projects in which the potential firms had participated. These programmes had primarily provided financing for R&D activities and were thus a key source for finding technologically intensive firms. Examples of these programmes are Helsinki NANO, FinNano and Groove. In addition, Finnish competence clusters, such as the Nanobusiness and Cleantech clusters, which are parts of the Finnish Centre of Expertise Programme, were used as sources for sample firms. Financial data were obtained from a database that was compiled by Suomen Asiakastieto Oy. However, the data set did not contain all of the required information; therefore, additional data were obtained from the Finnish trade registry. Additional data were requested from the interviewees in situations in which these data were otherwise inaccessible. These data included the newest employment and revenue numbers, which had not been updated in the aforementioned database.

4.2 Survey

The survey was designed based on the topics of the literature review and previous studies conducted by the Research Institute of the Finnish Economy (ETLA). The latter studies provide an opportunity to compare the results of this survey to previous surveys if needed. The survey is presented in Appendix A.

The survey was conducted in July and August 2011 using telephone interviews with an average duration of approximately 35 minutes. Of the 123 recognised firms, 53 managers each representing their respective firms were interviewed. In total, 53 firms were included in the study; consequently, the response rate of 43% is high.

Table 1 compares the interviewed and non-interviewed firms according to their respective founding year, number of employees, and revenue. Based on t-tests that determine whether the means of the two groups are equal when the variance is assumed to be unequal, no statistically significant difference can be observed between the groups. Therefore, no significant sample bias can be observed in the sample, and the sample is representative. The data that were used for this comparison are from 2009, as the 2010 data for the firms that were not interviewed were insufficient. However, one interviewed firm was not included in the regression analysis because the financial data for 2010 were unavailable.

The average founding year of the interviewed firms was approximately 1998; thus, on average, the firms were 13 years old. According to the survey data, the firms had sold their first product

Table 1 Comparison of interviewed and non-interviewed firms

	Interviewed	*Not interviewed*
Founding year		
Obs	53	70
Mean	1997.8	1997.3
Med	1999	2000
SD	8.22	7.85
t-test (Difference ! = 0)	*p*	*0.750*
Employees		
Obs	53	66
Mean	30.8	28.2
Med	10	13.5
SD	53.53	43.12
t-test (Difference ! = 0)	*p*	*0.772*
Revenue (€)		
Obs	53	65
Mean (1000)	5 030	14 900
Med (1000)	582	1 477
SD (1000)	10 150	78 200
t-test (Difference ! = 0)	*p*	*0.318*

or service to a customer one year after the founding of the firms. In addition, early activity excludes the possibility that a firm was created with the intention of postponing use, and in many cases, the innovation or invention on which the products or services are based were most likely invented before the incorporation of the firm. However, 36% of the interviewed firms were spinoffs or were based on another firm, but some interviewees representing spinoffs from university research teams may have indicated that they did not belong to the above group.

There are large differences between the mean and median number of employees. The explanation is that most of the firms are small, but a few larger firms increase the mean value to a relatively high level. The high standard deviation (53.5) supports this conclusion. The deviation in revenue is high among the interviewed firms, as the mean is higher than the median by a factor of nearly 10, and the standard deviation is higher than the median by a factor of nearly 20. In conclusion, the median values more accurately represent the interviewed firms, which are generally young and small. These observations endorse the objectives of the sample selection.

Table 2 describes the main sources of income for the interviewed firms. For 88% of the interviewed firms, the main source of income is enterprises. Therefore, the interviewed firms primarily engage in transactions between businesses (B2B). In addition, 6% of firms specify the public sector as their main source of income, and only one firm primarily sells its products to consumers. Two firms (6% of the firms) obtain income from other sources. However, these interviewees noted that investors were financing their operations at that time and that enterprises were their main intended future customer group. Services are responsible for an average of 19% of revenues. In conclusion, the interviewed firms are quite homogenous in their source of income, and the sale of physical products is the primary method of generating income.

Table 2 Main sources of income

	Main source of income
Enterprises	88%
Consumers	2%
Public sector	6%
Other	4%

Table 3 describes how the interviewed firms viewed their placement in the supply chain. The distribution is even; the only slightly larger group is that of main contractors, who are represented by 38% of the interviewees. A main contractor is defined as responsible for designing and selling the end product. System providers, which are represented by 38% of the interviewees, are defined as being responsible for providing larger entities than subcontractors to the main contractors. Finally, 28% of interviewees defined themselves as subcontractors.

Table 3 Main position in the supply chain

	Main position in supply chain
Subcontractor	28%
System provider	34%
Main contractor	38%

Table 4 describes the geographical scope of the operations of the interviewees. According to the results, 68% of the interviewed firms are Finnish exporters operating in Finland. The second largest group consist of firms that operate only in Finland and that constitute 17% of the interviewed firms. The third group is multinational firms, which represent 15% of the interviewed firms, and most of these firms have a foreign parent. In total, 34% of the interviewed firms are subsidiaries, and 50% of the subsidiaries have a foreign parent. Exports are responsible for an average of 60% of the revenue of a firm that exports products or services, and services account for an average of 13% of the total exports in terms of revenue.

Table 4 Geographical scope of operations

	Firm operates
Only in Finland	17%
Exporter	68%
Multinational	15%

Table 5 presents the distribution of technologies that the interviewed firms use or technologies in which the firms' products are applied. This distribution is based on the opinions of the interviewees, and a firm can simultaneously use multiple technologies. For example, 29% of the firms that use nanotechnology are developing renewable energy technologies. In summary, the largest technology group is renewable energy technologies; this group includes 47% of the interviewees. The second largest group is environmental technologies (36%), the third largest group is nanotechnology (26%), and the fourth largest group is biotechnology (8%). However, the only responses that are included here are those that indicated the 'extensive use' of technology in a four-grade scale from one (1) to four (4) in which only the end values one (1) and four (4) were defined as 1='none' to 4='extensive use'.

Table 5 Technology distribution

	Which technologies the firm uses or applies (interviewee's opinion)
Biotechnology	8%
Nanotechnology	26%
Environmental technologies	36%
Renewable energy technologies	47%

Table 6 indicates the number of the interviewed firms plan to increase their revenue or employment by more than 50% during the next two years. The above definition is adapted from the OECD's definition of high-growth firms (OECD-Eurostat, 2007). More than three-fourths of the interviewed firms aim to grow more than 50% during the next two years. In sum, most of the firms are growth driven. However, as Nikulainen et al. (2012, forthcoming) observed when studying the Finnish biotechnology business, expected and realised revenues often differ. The authors reveal that only 1 of 21 firms was able to grow more rapidly than expected from 2004 to 2008. In conclusion, the interviewed firms have high growth expectations, but their actual growth is not connected with their expectations.

Table 6	Firms that aim to grow by more than 50% during the next two years
	Aim to grow
Yes	77%
No	23%

This chapter has described the sample and now proceeds to discuss the formation of the activity measures that are used in the empirical analysis.

4.3 Activity measures

A set of questions was posed to the interviewed firms to measure how co-operational relationships have developed between them and the actors with whom they have been connected during the last three years. The set of questions consisted of seven actor groups and three themes, which were research and development, manufacturing, and marketing and distribution. The interviewees were asked to evaluate the strength of their relationship with every actor and theme on a scale of one (1) to four (4) in which one was 'not at all important' and four 'very important'. In addition, the actors were divided into domestic and foreign actors, and the questions were asked with respect to the following time scale: the time of the interview and approximately three years ago. In total, 84 variables were created. The actor groups and themes are presented in Table 7. The interviewees were also asked to evaluate how many important actors are in every group. This question was asked as an entity and was not divided into themes as in the activity measurement.

Table 7	List of actors and themes					
Theme	*R&D*		*Manufacturing*		*Marketing & Distribution*	
	in Finland	*Abroad*	*in Finland*	*Abroad*	*in Finland*	*Abroad*
Actor						
Large customers (over 50 people)	•	•	•	•	•	•
Small customers	•	•	•	•	•	•
Competitors	•	•	•	•	•	•
Distributors	•	•	•	•	•	•
Suppliers	•	•	•	•	•	•
Universities	•	•	•	•	•	•
Research institutes	•	•	•	•	•	•

Table 8 presents the proportion of interviewees who valued their R&D relationship with a certain actor group as 'very important' (4), and the share of interviewees who have an 'important' (3) or 'very important' (4) relationship is shown on the right side. Notably, large foreign

customers constitute the most important R&D actor group, and large Finnish customers (employing more than 50 people) and suppliers constitute the second most important actor group. Compared with large customers, universities and research institutes have a minor role, given that the firms are primarily technologically intensive. Furthermore, 85% of the interviewed firms have launched new or significantly improved products, and 49% have launched new or significantly improved services during the last three years. For the additional answers at level three, the most important observation is that 47% of the interviewees rank the importance of relationships with universities as level three or four. However, the distribution is significantly lower for relationships with foreign universities and research universities at both levels.

Table 8 Distribution of the importance of R&D relationships

Importance level	*4*		*3–4*	
	in Finland	*Abroad*	*in Finland*	*Abroad*
Large customers (employs over 50 people)	17.0%	20.8%	47.2%	49.1%
Small customers	11.3%	0.0%	28.3%	15.1%
Competitors	0.0%	0.0%	1.9%	1.9%
Distributors	1.9%	5.7%	13.2%	13.2%
Suppliers	17.0%	9.4%	37.7%	43.4%
Universities	7.5%	3.8%	47.2%	20.8%
Research institutes	11.3%	3.8%	30.2%	13.2%

Table 9 presents the proportion of interviewed firms that valued their manufacturing relationship with a certain actor group as 'very important' (4) and 'important' (3) or 'very important' (4). Suppliers are the only group with several relationships at level 4 ('very important'). The interviewed firms have relationships with suppliers especially and to some extent with large and small customers at levels 3 and 4. These relationships include both Finnish and foreign entities.

Table 9 Distribution of the importance of manufacturing relationships

Importance level	*4*		*3–4*	
	in Finland	*Abroad*	*in Finland*	*Abroad*
Large customers (employs over 50 people)	1.9%	1.9%	26.4%	13.2%
Small customers	7.5%	0.0%	18.9%	9.4%
Competitors	0.0%	0.0%	1.9%	0.0%
Distributors	1.9%	5.7%	3.8%	7.5%
Suppliers	17.0%	11.3%	45.3%	37.7%
Universities	1.9%	0.0%	5.7%	0.0%
Research institutes	1.9%	0.0%	7.5%	0.0%

Table 10 presents the proportion of interviewees who valued their marketing and distribution relationship with a certain actor group as 'very important' (4) and 'important' (3) or 'very important' (4). Furthermore, the foreign distributor group is the only group that includes more than 10% of the interviewees with a 'very important' relationship. A comparison of the differences between the Finnish and foreign groups to which the interviewees assigned importance levels of 3 or 4 shows that the interviewed firms have more relationships with foreign distributors and foreign large customers than with Finnish firms; however, with respect to small customers, Finnish contacts prevail. The explanation may be that the interviewed firms do not use distributors in Finland to the same extent as in export markets and that the international focus of firms tends to be devoted to large customers who are likely to order larger quantities compared with small customers.

Table 10 Distribution of the importance of marketing & distribution relationships

Importance level	*4*		*3–4*	
	in Finland	*Abroad*	*in Finland*	*Abroad*
Large customers (employs over 50 people)	3.8%	3.8%	9.4%	18.9%
Small customers	3.8%	0.0%	15.1%	3.8%
Competitors	1.9%	0.0%	1.9%	0.0%
Distributors	9.4%	11.3%	18.9%	30.2%
Suppliers	3.8%	0.0%	9.4%	1.9%
Universities	1.9%	0.0%	1.9%	1.9%
Research Institutes	0.0%	0.0%	1.9%	1.9%

Table 11 describes the number of actor groups with which the interviewees had important relationships. The reported count is the median to reduce the distortion effect on the average count that is caused by several large counts. The median number of large customers with which the interviewed firms have co-operational relationships is three for both Finnish and large foreign customers. The median count for small Finnish customers and small foreign customers is two. This result is encouraging because relationships with customers are beneficial for many reasons, including for the purposes of information exchange and knowledge acquisition (Yli-Renko et al., 2001). Furthermore, the number of co-operational relationships with customers should be optimised to include as many relationships as possible while ensuring that these relationships remain manageable (Yli-Renko and Janakiraman, 2008). However, 23% of the interviewees reported that one customer is responsible for more than one-third of their total sales; thus, these firms may be excessively dependent on one customer.

Generally, cooperation with competitors is nearly non-existent. Furthermore, cooperation with Finnish distributors is insignificant, but cooperation with foreign distributors is common. Indeed, this result appears to confirm that the interviewed firms typically distribute their products or services without external actors in Finland and exploit foreign distributors in other markets. Thus, the interviewed firms can utilise the local knowledge that the foreign distributors may have elsewhere. One concern is that the median number of co-operation-

Table 11 The median number of important co-operational relationships

Count (median)	*in Finland*	*Abroad*
Large customers (employs over 50 people)	3	3
Small customers	2	1
Competitors	0	0
Distributors	0	3
Suppliers	3	2
Universities	2	0
Research institutes	1	0

al relationships with foreign universities or foreign research institutes is zero. For example, many studies have identified these science partners as important sources of radical innovations and information brokering, including the works of Pittaway et al. (2004) and Ferrary and Granovetter (2009). Finally, both Finnish and foreign suppliers are well connected, as the median numbers are three and two, respectively.

New variables were created to better understand how the relationships have evolved during the last three years. The new variables were created for the specific purpose of testing the hypotheses. Table 12 describes how the allocation was performed. For instance, if an R&D relationship with large Finnish customers was 'very important' three years ago and remains 'very important', then the value one was assigned to the new change variable. Additionally, if a relationship with large Finnish customers was less than 'very important' three years ago and is now 'very important', then the value two was assigned to the change variable. The value three was assigned if a 'very important' relationship subsequently lost its importance. If a relationship has remained at a level that was lower than the 'very important' level during the last three years, then the value four '4' was assigned to the change variable. The process described above was performed for each of the seven actors in each of the three themes (R&D, manufacturing, and marketing and distribution).

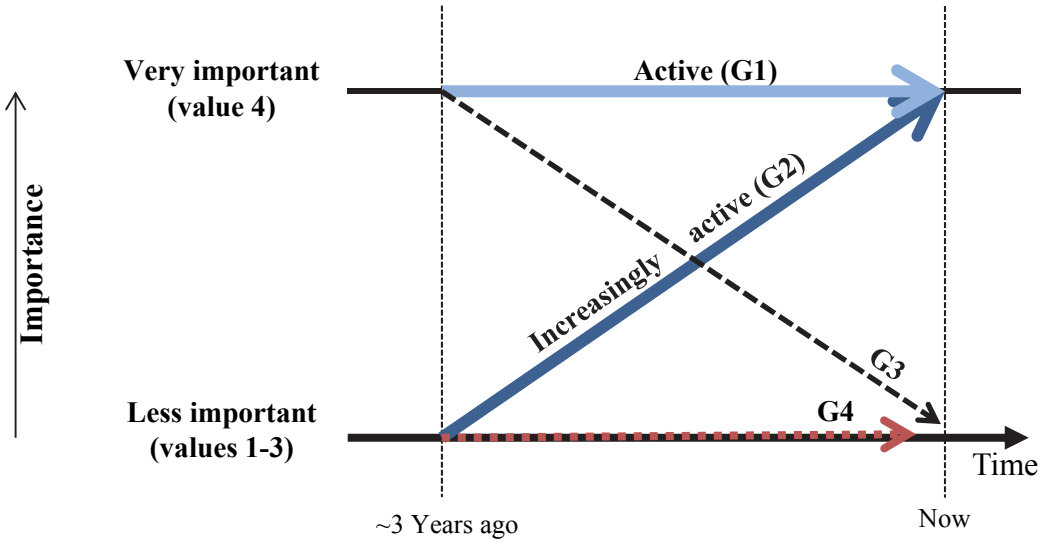
Table 12 The recognised activity levels and the changes in importance in each activity level

	3 years ago		*Now*
Group			
G1	4	→	4
G2	1–3	→	4
G3	4	→	1–3
G4	1–3	→	1–3

When the above process was completed, the number of occurrences of each change group was counted, and every actor in each of the three themes was included. Based on the results, the firms can be categorised into three different groups. The first group includes the firms that

are relatively active compared with other firms. In other words, these firms have more changes belonging to group one (G1) compared with other interviewed firms. The second group consists of the firms that have increased the number of very important co-operational relationships during the last three years; that is, these firms have more changes belonging to group two (G2) compared with other firms. Henceforth, the former firms are termed 'active', and the latter firms are termed 'increasingly active'. These concepts are presented in Figure 10.

Figure 10 The concepts of active and increasingly active firms



The largest group of firms consists of passive firms that are neither active nor increasingly active. Finally, only three of the fifty-three interviewed firms reported more than one change in the importance of a co-operational relationship from the very important level to a lower level during the last three years.

5 Methodology

This chapter describes how firm performance is measured; explains the dependent variables, the independent variables, and the control variables; and discusses the model that is used to test the hypotheses.

5.1 Measuring performance

There are numerous possible methods of measuring firm performance. For instance, in their literature review, Achtenhagen et al. (2010) argue that empirical growth studies use different measurements of growth. Furthermore, the authors report that sales growth and employment growth are the two most commonly used growth measures. According to their study, other common growth measures include growth intentions, profitability, growth strategies, and combinations of these measures.

Furthermore, in the literature review of Gilbert et al. (2006), the authors report there is no single prime measurement for new venture growth and that sales, employment, and market share are the three most commonly employed indicators. In addition, Gilbert et al. (2006) argue that measuring growth in employment is appropriate, for instance, when a firm has not launched its products or services. The authors also state that growth in employment can demonstrate an expansion in a firm's scope of operations or an immediate increase in business. Furthermore, one way to consider the recruiting of a new employee is to view this action as an investment that is made when the net present value of the recruitment is positive. Therefore, recruitment can be viewed as being connected with the growth prospects of a firm.

Recently, policy makers have attempted to restore economic growth after the recent economic crises and have recognised growth firms as one of the most promising sources of growth because these firms have been identified as high net job creators (OECD, 2010). Furthermore, the OECD-Eurostat (2007) defines high-growth enterprises as follows:

> *'All enterprises with average annualised growth greater than 20% per annum, over a three year period should be considered as high-growth enterprises. Growth can be measured by the number of employees or by turnover.'*

Based on the OECD-Eurostat (2007), the works of Gilbert et al. (2006) and Achtenhagen et al. (2010), and the scope of the current research, sales growth and employment growth are the two most deliberate growth measures for this study. Consequently, these two performance measures are used to test hypotheses 1a and 1b.

The following section first describes the two dependent variables that are defined above, revenue growth and employment growth, which are used to test hypotheses 1a and 1b. Second, the section describes the third dependent variable, which is the share of exports, to be used to test hypotheses 2a and 2b.

5.2 Dependent variables

Revenue growth

Hypotheses 1a and 1b explore the possible connection between the growth rate of firms and their network activity. The first dependent variable measures firm growth in terms of revenue growth. The data for this variable were primarily collected from the Finnish Trade Register, and the interviewees provided the missing data during and after the survey. The formula that was used to calculate the growth rates is presented below, and the growth rates are formulated as geometric means (OECD-Eurostat, 2007).

$$g_r = \sqrt{\frac{Revenue_{2010}}{Revenue_{2008}}} - 1 \quad (1)$$

Figure 11 shows that the distribution of growth rates is skewed and that the rates are thus not normally distributed. The data for the variable were transformed using the logarithmic transformation that was presented in Formula 2 to attain the normality that was required for the regression analysis (Greene, 2003). Furthermore, this transformation was required because the normality and homoscedasticity of variables are generally connected (Greene, 2003). The dis-

tribution of the transformed growth of revenue is presented in Figure 12, which shows a normal distribution. Therefore, the transformed growth of revenue is used as the dependent variable.

$$\text{The growth of revenue} = Log(1 + g_r) = Log\left(1 + \left(\sqrt{\frac{Revenue_{2010}}{Revenue_{2008}}} - 1\right)\right) \quad (2)$$

Figure 11 Distribution of g_r

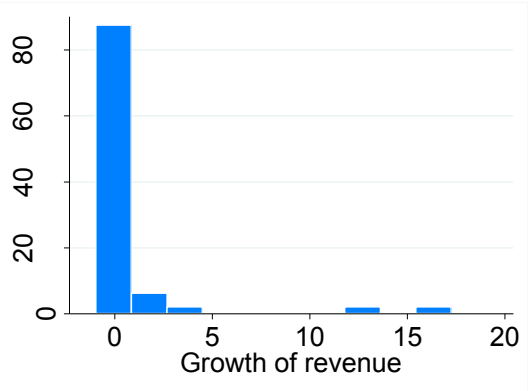
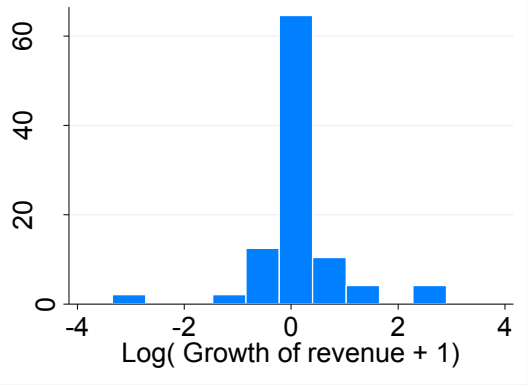


Figure 12 Distribution of Log (1+g_r)

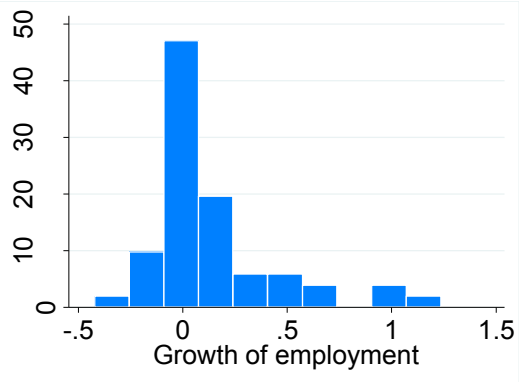


Employment growth

The second dependent variable is the growth of employment. The data for the variable were primarily collected in a manner that is similar to that used for the above variable from the Finnish Trade Register, and the interviewees provided missing data during and after the survey. The formula that was used to calculate the growth rates is presented below, and the growth rates were formulated as geometric means (OECD-Eurostat, 2007). The distribution of the growth of employment is presented in Figure 13, and it is rather normally distributed.

$$\text{The growth of emploment} = g_e = \sqrt{\frac{Employees_{2010}}{Employees_{2008}}} - 1 \quad (3)$$

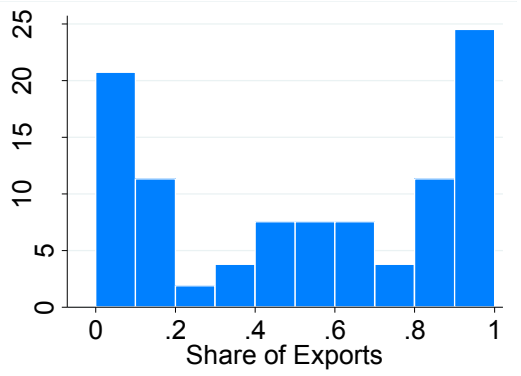
Figure 13 The growth of employment



Exports

The third dependent variable is exports, which is the share of exports of the revenue. The export variable is used as a proxy to measure the extent of a firm's internationalisation. This dependent variable was created to explore the possible connection between internationalisation and network activity that is proposed in hypotheses 2a and 2b. The variable takes values between 0 and 1 and was requested of the interviewees during the interview. A value of 1 indicates that a firm exports all of its production abroad. The distribution of exports is shown in Figure 14. Specifically, Coviello (2006) and Prashantham and Dhanaraj (2010) argue that networks are vital when internationalising a firm and that network relationships should evolve during and after the internationalisation process. Consequently, the use of the share of exports as the dependent variable extends the analysis that is presented in the study.

Figure 14 The share of exports



5.3 Independent variables

This section describes the independent variables that are used to test the hypotheses. The first two independent variables investigate the connections that are proposed by the hypotheses. Finally, this section describes the more specific independent variables that analyse whether there are differences between the various types of relationships.

Active

The first independent variable, 'active', is derived from the activity measures that are described in section 3.3 and takes a binary value of 0 when a firm is not recognised as belonging to a group of active firms and a value of 1 when a firm is recognised as belonging to such a group. A firm is recognised as belonging to this group if the firm has active relationships with three or more network actors, as described in section 3.3.

Increasingly active

The second independent variable, 'increasingly active', is derived from the activity measures that are described in section 4.3 and takes a binary value of 0 when a firm is not recognised as belonging to the group of increasingly active firms and a value of 1 when a firm is recognised as belonging to this group. A firm is recognised as belonging to the group if it has increasingly active relationships with three or more network actors, as described in section 4.3. The following independent variables are created to further study the possible connection between network activity and the dependent variables. Table 13 shows the tabulation of the 'active' and 'increasingly active' dependent variables. The tabulation states that only one firm is both 'active' and 'increasingly active'.

Table 13 Tabulation of the activity measures

		Increasingly active	
		No	***Yes***
Active	***No***	38	7
	Yes	7	1

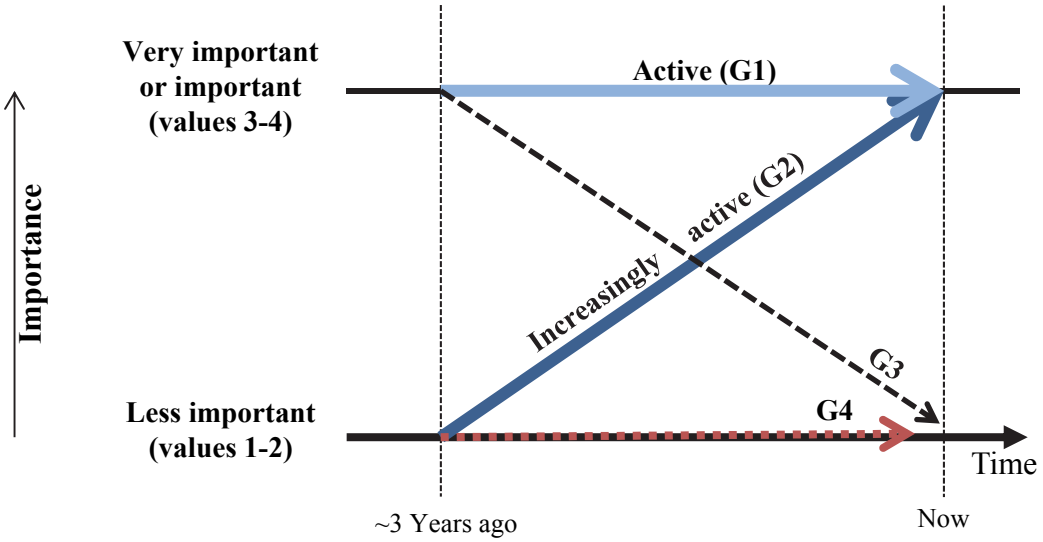
Specific independent variables

The following six independent variables are specifically formed to determine whether a certain relationship type has a more evident connection with the dependent variables than other types.

R&D active

This variable is constructed similarly to the 'active' independent variable. However, only R&D relationships are considered for this variable, and both manufacturing relationships and marketing and distribution relationships are excluded compared with the variable 'active'. The 'R&D active' variable takes a binary value of 1 when a firm has four or more active R&D relationships with actors in the network and 0 otherwise. However, for this and the following five variables, the limit to be included in the group is lowered; therefore, the 'important' (3) and 'very important' (4) responses on a scale of 1 to 4 are observed to be an active relationship. Figure 15 shows the new concept. The justification for this change is that the limit that is used for the first two independent variables would have admitted only a few firms into the 'active' group; hence, the analysis would not have been reasonable. The same reason also applies to the following independent variables.

Figure 15 An adaptation of the concepts of active and increasingly active firms



R&D increasingly active

In this independent variable, only R&D relationships are considered, and both manufacturing relationships and marketing and distribution relationships are excluded compared with the variable 'increasingly active'. The 'R&D increasingly active' variable takes a binary value of 1 when a firm has four or more increasingly active R&D relationships with actors in the network and 0 otherwise.

Manufacturing active

Only manufacturing relationships are considered in this independent variable, and both R&D relationships and marketing and distribution relationships are excluded compared with the variable 'active'. The variable 'manufacturing active' takes a binary value of 1 when a firm has two or more active manufacturing relationships with actors in the network and 0 otherwise. The limit is lower than in the two previous variables because activity is generally lower in manufacturing relationships and marketing and distribution relationships than in R&D relationships. The difference that is described above can be observed when one compares Table 8, Table 9, and Table 10. Additionally, the above reason is observed in the following three independent variables, which also have a lower limit.

Manufacturing increasingly active

In this independent variable, only manufacturing relationships are considered, and both R&D relationships and marketing and distribution relationships are excluded compared with the variable 'active'. The 'manufacturing increasingly active' variable takes a binary value of 1 when a firm has two or more increasingly active manufacturing relationships with actors in the network and 0 otherwise.

Marketing & distribution active

In this independent variable, only marketing and distribution relationships are considered, and both R&D relationships and manufacturing relationships are excluded compared with the

variable 'active'. The 'marketing & distribution active' variable takes a binary value of 1 when a firm has two or more active manufacturing relationships with actors in the network and 0 otherwise.

Marketing & distribution increasingly active

In this independent variable, only marketing and distribution relationships are considered, and both R&D relationships and manufacturing relationships are excluded compared with the variable 'increasingly active'. The 'marketing & distribution increasingly active' variable takes a binary value of 1 when a firm has two or more increasingly active manufacturing relationships with actors in the network and 0 otherwise.

5.4 Control variables

This section describes the control variables of age, revenue, employees, R&D share, bio, nano, environmental, and renewable.

Age

A control variable was added to control the effect of firm age in the regression model. Firm growth rates or shares of exports are assumed to be linked with firm age. Therefore, the effect must be controlled for in the model. Data from the Finnish Trade Register were used to calculate firm age. Firm age is measured in years, and the zero point is set at the year 2011. A logarithmic transformation was performed to conform to the normality assumption prior to using the variable in the regression model.

Revenue

Similar to age, revenue is assumed to be linked to the growth rate of revenue and possibly to the share of exports and therefore must be controlled. As with the age variable, a logarithmic transformation was performed to conform to the normality assumption of the model. The revenue data were derived in a manner that was similar to those for the growth of revenue. Revenue is used as a control variable when the dependent variables (i.e., the revenue growth rate and the share of exports) are revenue related.

Employees

Similar to age and revenue, the number of employees is assumed to be linked to firm growth rates and therefore must be controlled. As with the age and revenue variables, a logarithmic transformation was performed to conform to the normality assumption of the model. The data were derived in a manner that was similar to those for the employment growth rate. The number of employees is used as a control variable when the dependent variables are employment related. The logarithmic transformations of the number of employees and revenue are highly correlated (0.749) and thus are not used simultaneously in the regression analysis.

R&D share

The third control variable is the share of revenue that is used for R&D. This variable adopts values between 0 and 1, and the values of the variable are obtained from the interviewees. The R&D share is considered because it exposes the R&D activity of the firms, and it also expresses the life-cycle stage of the firms and may thus have an effect on the growth rate.

The last four control variables are technology based and are used as proxies for the industries in which the firms operate.

Bio

Four industry control variables were created to account for the differences among the industries that are investigated in the study. The first control variable is 'bio' and is a binary variable with the value of 1 when a firm uses biotechnology or if the end product or service is used in the biotechnology industry 'extensively' according to the interviewee and 0 when a firm uses biotechnology or if the end product or service is used in the biotechnology industry less than 'extensively'. Biotechnology was added as a control variable because previous studies have shown that biotechnology and nanotechnology are interconnected in Finland to some extent (Nikulainen and Kulvik, 2009). The use of biotechnology or the use of the end product or service in the biotechnology industry was rated by the interviewees on a scale of one (1) to four (4), in which one was 'none' and four was 'extensive'.

Nano

This variable and the following two control variables are derived from the scope of the study. The second industry variable is 'nano' and is a binary variable that takes the value of 1 when a firm uses nanotechnology or if the end product or service is used in the nanotechnology industry 'extensively' according to the interviewee and 0 when a firm uses biotechnology or if the end product or service is used in the nanotechnology industry less than 'extensively'. The use of nanotechnology or the use of the end product or service in the nanotechnology industry was rated by the interviewees on a scale of one (1) to four (4), in which one was 'none' and four was 'extensively'.

Environmental

The third industry variable is 'environmental' and is a binary variable that takes the value of 1 when a firm uses environmental technology or if the end product or service is used in the environmental technology industry 'extensively' according to the interviewee and 0 when a firm uses environmental technology or if the end product or service is used in the environmental technology industry less than 'extensively'. The use of environmental technology or the use of the end product or service in environmental technology industry was rated by the interviewees on a scale of one (1) to four (4), in which one was 'none' and four was 'extensively'. Environmental technology is an umbrella term for various technologies, such as air pollution control, water pollution control, and solid waste management. In addition, renewable energy technologies can be listed below the term, but for the purposes of this study, the term is a separate variable.

Renewable

The fourth and last industry variable is 'renewable' and is a binary variable that takes the value of 1 when a firm uses renewable energy technologies or if the end product or service is used in the renewable energy technology industry 'extensively' according to the interviewee and 0 when a firm uses renewable energy technologies or if the end product or service is used in the renewable energy technology industry less than 'extensively'. The use of renewable energy technologies or the use of the end product or service in the renewable energy technology industry was rated by the interviewees on a scale of one (1) to four (4), in which one was 'none' and four was 'extensively'. The technologies that are listed under renewable energy technologies include solar, biomass, wind, ocean, geothermal, and hydropower technologies.

5.5 Model

The base model in the study uses an ordinary least squares (OLS) regression to test hypotheses 1a-2b. The robust standard errors by Huber (1967) and White (1980) are used in the regression to reduce the effect of unidentified heteroscedasticity. The significances of the coefficients of the independent variables are one-tailed probabilities, and the significances of the control variables are two-tailed probabilities. The ordinary least square estimate in matrix form is formulated below (Greene, 2003).

$$\boldsymbol{y} = \boldsymbol{X\beta} + \boldsymbol{\varepsilon} \tag{4}$$

6 Results

This chapter provides the empirical results of the analysis. The first section addresses the actors who assist the interviewed firms in developing new co-operational relationships and the actors who are the key information sources. The second section provides the descriptive statistics. The third section describes the results of the regression analysis, and the fourth section analyses the robustness of these results. The fifth section summarises the results.

6.1 Background analysis of activity

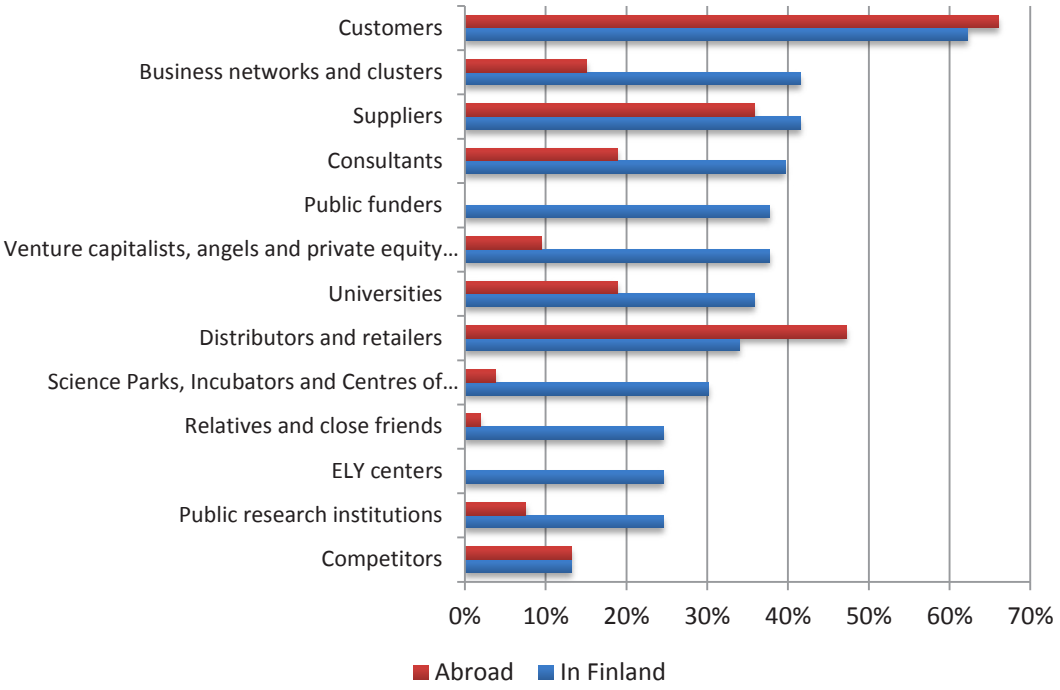
New co-operational relationships

This section begins by examining the importance of foreign actors when the interviewees create new co-operational relationships. The results indicate that 70% of the interviewees emphasised the importance of foreign actors. Furthermore, at a 10% confidence level, the test of proportions did not identify statistically significant differences between the firms that are recognised as active and not active or between the firms that are recognised as increasingly active and not increasingly active (Acock, 2010). In conclusion, the result clearly identifies the importance of relationships with foreign actors.

Second, this section analyses whether existing relationships with certain actor groups had substantially assisted the interviewed firms in creating new co-operational relationships in the Finnish market or in the foreign markets during the last three years (e.g., new business relationships or research relationships). According to the results in Figure 16, the most beneficial actor group in the Finnish market for creating new relationships is customers (60% of the interviewees agree), and the second most important group is suppliers (42%), who are tied to business networks and clusters (42%). The importance of customers is consistent with the earlier findings that were reported in section 4.3, in which large customers are the most important R&D partners. The results indicate that competitors (13%), relatives and close friends (25%), and ELY centres[1] (25%) are the four least beneficial actor groups. Interestingly, the interviewees perceive venture capitalists, angels, and private equity investors (38%) were found to be as beneficial as public funders (38%) and more beneficial than ELY centres (25%).

[1] The Centres for Economic Development, Transport and the Environment

Figure 16 The actors who have benefitted the interviewees substantially when developing new co-operational relationships in Finnish or foreign markets



In the foreign market, the most beneficial actor group is customers (66%), and the second most beneficial group is distributors and retailers (47%). Additionally, these two groups are the only actor groups that most of the interviewees perceived to be beneficial in foreign markets compared with the Finnish market for creating new co-operational relationships. Remarkably, public funders and ELY centres are the least beneficial actors, as the interviewees perceived them as less beneficial than the other actors in foreign markets. In general, the results indicate that in foreign markets, the upstream actors in the value chain are the most beneficial for the creation of new co-operational relationships. Only 15% of the interviewees perceived existing relationships with business networks and clusters as beneficial for the creation of new co-operational relationships in foreign markets. However, Prashantham and Dhanaraj (2010) argue that business networks provide a cost-efficient method of forming new relationships. Furthermore, the subsequent sub-section extends this analysis by discussing which information sources are the most important when entrepreneurs are envisioning the future state of their businesses.

Sources of information

Networks and network relationships provide channels for information that is required for successful business operations (Granovetter, 1973, Uzzi, 1997, Teece, 2010). In the survey, the interviewees defined the relative importance of certain information sources in creating visions of the future business landscape. Figure 17 provides the average importance levels of the information sources. The question was posed on a scale of one (1) to four (4), in which one was defined as 'not at all important' and four as 'very important'. The question was adapted from the Community Innovation Survey (CIS) by Eurostat (2008).

Figure 17 The most important sources of information during the last three years

Typically, the most important sources of information are clients and customers. The second most important sources are those within an interviewee's firm or enterprise group. These two sources are notably more important than other sources. The least important sources are professional and industry associations in conjunction with governmental or public research institutions. Interestingly, scientific journals and trade or technical publications are highly important sources of information compared with universities or other higher education institutes, which are perceived as less important. This result may suggest that the interviewees have not developed relationships with local universities with relevant expertise, that local universities may not have relevant expertise, or that the firms wilfully develop their products or services independently. The relative insignificance of governmental or public research institutes is especially notable because a greater number of interviewees have formed very important R&D relationships with research institutes compared with universities. Moreover, these results are consistent with the findings of the Finnish National Community Innovation Survey (Official Statistics of Finland, 2008).

Overall, this section has demonstrated that customers are the most important sources of information. Moreover, customers constitute the most beneficial actor group for entrepreneurs who are developing new co-operational relationships. Next, this study proceeds to test the hypotheses. Thus, the following section provides descriptive statistics for the regression analysis. Additionally, this section has provided valuable observations, which will assist in the analysis of the results of the regression.

6.2 Descriptive statistics

Table 14 provides the descriptive statistics for the data. These data include 52 observations representing 52 different managers who each represent one firm. However, employment growth rates are available for 51 firms, and revenue growth rates are available for 48 firms. Table 15

shows the pairwise correlations of the variables. In Table 14, variables 1 to 3 are the dependent variables, variables 4 to 11 are the independent variables, and variables 12 to 19 are the control variables. As the 'active' and 'increasingly active' variables are both binary variables, the mean values that are reported in Table 14 indicate that 15% of the firms are active or increasingly active. Furthermore, the correlation between the variables is only -0.031 and not significant; thus, this finding supports the assumption that the groups are formed by different firms.

Table 14 Descriptive statistics

Variable	*Obs*	*Mean*	*SD*	*Min*	*q25*	*Median*	*q75*	*Max*
Dependent variables								
Employment growth	51	0.141	0.320	-0.423	-0.047	0.031	0.190	1.236
Revenue growth	48	0.138	0.861	-3.349	-0.143	0.060	0.345	2.905
Exports %	52	0.530	0.383	0.000	0.251	0.535	0.925	1.000
Independent variables								
Active	52	0.154	0.364	0.000	0.000	0.000	0.000	1.000
Incr. Active	52	0.154	0.364	0.000	0.000	0.000	0.000	1.000
R&D Active	52	0.192	0.397	0.000	0.000	0.000	0.000	1.000
R&D Incr. Active	52	0.173	0.382	0.000	0.000	0.000	0.000	1.000
Manuf. Active	52	0.231	0.425	0.000	0.000	0.000	0.000	1.000
Manuf. Incr. Active	52	0.245	0.434	0.000	0.000	0.000	0.000	1.000
Market. & Distr. Active	52	0.173	0.382	0.000	0.000	0.000	0.000	1.000
Market. & Distr. Incr. Active	52	0.173	0.382	0.000	0.000	0.000	0.000	1.000
Control variables								
Age	52	2.402	0.650	1.099	1.869	2.485	2.890	3.555
Employees	52	2.571	1.302	0.000	1.694	2.350	3.503	5.521
Revenue	51	13.886	2.217	6.867	12.675	13.787	15.517	18.198
Bio	52	0.077	0.269	0.000	0.000	0.000	0.000	1.000
Nano	52	0.269	0.448	0.000	0.000	0.000	1.000	1.000
Environmental technology	52	0.361	0.480	0.000	0.000	0.000	1.000	1.000
Renewable energy tech.	52	0.462	0.503	0.000	0.000	0.000	1.000	1.000
R&D %	52	0.313	0.324	0.020	0.068	0.150	0.450	1.000

Table 15 Pairwise correlations for activity

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Employment growth																		
2	Revenue growth	0.504 **																	
3	Exports %	-0.124	0.037																
4	Active	-0.041	0.035	0.204															
5	Incr. Active	0.329 *	0.264 +	-0.087	-0.031														
6	R&D Active	-0.120	-0.103	0.394 **	0.201	-0.069													
7	R&D Incr. Active	0.199	0.313 *	0.028	-0.191	0.371 **	0.039												
8	Manuf. Active	0.110	0.204	0.187	0.150	0.024	0.200	-0.005											
9	Manuf. Incr. Active	0.232	0.011	-0.136	0.127	0.372 **	0.061	0.209	-0.204										
10	Market. & Distr. Active	-0.045	-0.026	0.066	0.371 **	0.090	0.167	0.063	0.116	0.326 *									
11	Market. & Distr. Incr. Active	0.078	-0.092	0.047	0.090	0.511 **	0.167	0.197	0.116	0.209	0.331 *								
12	Age	-0.099	-0.156	0.041	-0.223	-0.200	-0.078	-0.051	-0.016	-0.107	-0.162	-0.244 +							
13	Employees	-0.126	-0.087	0.143	0.000	-0.155	0.222	0.152	0.079	-0.003	0.064	-0.245 +	0.245 +						
14	Revenue	-0.108	0.277 +	0.088	-0.022	-0.144	0.152	0.117	0.084	-0.137	-0.011	-0.361 **	0.326 *	0.749 **					
15	Bio	0.109	0.024	-0.063	-0.121	0.279 *	-0.138	0.251 +	0.187	0.169	0.061	0.251 +	0.164	-0.051	-0.105				
16	Nano	0.069	-0.025	0.366 **	-0.014	-0.133	0.367 **	-0.043	0.085	0.056	-0.043	0.071	0.130	0.066	-0.065	-0.171			
17	Environmental technology	0.191	0.274 +	-0.149	0.234 +	0.015	-0.159	-0.024	0.160	0.123	0.081	-0.024	-0.092	0.020	0.183	0.084	-0.269 +		
18	Renewable energy technologies	0.416 **	0.209	-0.178	0.235 +	0.024	0.124	-0.025	0.121	0.252 +	-0.025	-0.025	-0.314 *	0.120	0.110	0.016	-0.223	0.476 **	
19	R&D %	0.326 *	0.195	0.052	0.168	0.232 +	0.062	0.091	0.095	0.207	0.121	0.232 +	-0.511 *	-0.335 *	-0.616 **	0.135	0.123	-0.031	0.141

+Significant at 10%; *Significant at 5%; **Significant at 1%.

6.3 Regression analyses

This section describes the results of the ordinary least squares (OLS) regression. Hypotheses 1a and 1b are first studied by using the revenue growth rate and the employment growth rate as the dependent variables. Subsequently, the share of exports is used as the dependent variable for testing hypotheses 2a and 2b. Each sub-section uses six models to test the hypotheses. The first model tests the connection between relationship activity and the dependent variable in a generic model, and the model is the main test for the hypotheses. However, the four subsequent models are used to determine whether a certain relationship type can be recognised as the source of the connection that is proposed in the hypotheses. Finally, the sixth model tests the goodness of the other models. Furthermore, in each regression, the probability values for the independent variables are one-tailed, and those for the control variables are two-tailed. The justification for this method is that the hypotheses propose one-sided connections for the independent variables.

Revenue growth

The results of the regressions that test the connections between network activity and revenue growth are shown in Table 16. Furthermore, models 1 to 5 test hypotheses 1a and 1b. The dependent variable is a logarithmic transformation; thus, the resulting coefficients of the variables cannot be interpreted in a straightforward manner. However, model 1 clearly supports hypothesis 1b because according to the model, increasing activity has a significant and positive connection with revenue growth ($\beta = 0.780$, $p < 0.01$). The coefficient of determination is high (0.52). The adjusted coefficients of correlation are not reported, as the regressions are estimated with robust standard errors. Moreover, the F-test is significant at the 1% level, and the maximum VIF score is 2.01, which indicates that multicollinearity does not notably affect the results (Hair et al., 2006). However, the 'active' variable is not significant; thus, the model does not support hypothesis 1a.

Models 2 to 5 test whether the effect of active and increasingly active connections can be related to a certain theme, such as R&D, manufacturing, or marketing and distribution. The F-test values for models 2 to 5 are not significant at the 10% level; thus, the overall model in each case is not statistically significant. Therefore, the following analysis includes only observations and does not contribute to the testing of the hypotheses. Additionally, in model 2, R&D activity and revenue growth are negatively related ($\beta = -0.508$, $p < 0.05$), and in models 4 and 5, marketing and distribution activity is negatively related to revenue growth ($\beta = -0.492$, $p < 0.10$ and $\beta = -0.486$, $p < 0.05$).

In model 1, the control variables of 'revenue', 'environmental technologies', and 'R&D %' are significant at the 5% level. According to the model, 'revenue' has a positive connection with the growth rate; this result suggests that larger firms grow more rapidly than smaller firms when size is measured in revenue. Firms that are recognised as specialising in environmental technologies have a highly positive connection with revenue growth ($\beta = 0.505$, $p < 0.05$). Interestingly, R&D spending has a positive connection with revenue growth ($\beta = 1.999$, $p < 0.05$); thus, the results suggest that current R&D spending clearly has a positive effect on revenue growth rate.

Model 6, which does not include the independent variables, is not significant, as the F-value is not significant at the 10% level, and the coefficients of the control variables are also not signif-

icant. Additionally, the coefficient of determination is lower in model 6 than in model 1 (0.383 and 0.475, respectively). Hence, the independent variables in model 1 evidently improve the results of the regressions.

Table 16 Regression results and revenue growth as a dependent variable (OLS with robust S.E.)

Dependent:	*Revenue growth*					
Model:	*1*	*2*	*3*	*4*	*5*	*6*
Active	-0.336					
Incr. Active	0.780**					
R&D Active		-0.508*			-0.379	
R&D Incr. Active		0.398			0.378	
Manuf. Active			0.182		0.327	
Manuf. Incr. Active			-0.009		0.178	
Market. & Distr. Active				-0.492+	-0.486*	
Market. & Distr. Incr. Active				-0.053	-0.102	
Age	-0.089	-0.135	-0.047	-0.139	-0.178	-0.063
Revenue	0.264*	0.249*	0.246*	0.272*	0.253*	0.253
Bio	-0.579	-0.327	-0.297	-0.209	-0.451	-0.233
Nano	-0.126	0.034	-0.202	-0.220	-0.129	-0.173
Environmental technology	0.505*	0.312	0.415*	0.496*	0.380+	0.433
Renewable energy technologies	-0.047	0.051	-0.049	-0.120	-0.097	-0.046
R&D %	1.999*	1.772*	2.008*	2.255*	1.959*	2.025
Constant	-3.963*	-3.549+	-3.791*	-3.838*	-3.476*	-3.827
Obs	48	48	48	48	48	48
R^2	0.475	0.440	0.391	0.430	0.489	0.383
F	2.85*	1.36	1.20	1.52	1.15	1.55
Max VIF	2.40	2.55	2.39	2.52	2.82	2.36
Mean VIF	1.53	1.66	1.56	1.63	1.81	1.59

+Significant at 10%; *Significant at 5%; **Significant at 1%.

Employment growth

The analysis proceeds to use the employment growth rate as the dependent value to test hypotheses 1a and 1b from a different angle. The results of the regressions that tested the connections between network activity and employment growth rates are shown in Table 17. Similar to the previous sub-section, models 1 to 5 all test hypotheses 1a and 1b. Model 1 clearly supports hypothesis 1b but rejects hypothesis 1a. Furthermore, according to the model, increasing activity has a significant and positive connection with employment growth (β = 0.328, $p < 0.01$). Contrary to the predictions, relationship activity is negatively and significantly connected with the employment growth rate (β = -0.196, $p < 0.10$). The coefficient of determination is high (0.45). Furthermore, the F-test is significant at the 5% level, and the maximum VIF score is 1.76, which indicates that multicollinearity does not notably affect the results (Hair et al., 2006).

As in the previous sub-section, models 2 to 5 test whether the effect of active and increasingly active relationships can be specified to a certain theme, such as R&D, manufacturing, or marketing and distribution. The F-test value is significant for model 2 only at the 5% level, and the values for models 3 to 5 are not significant at the 10% level; thus, the overall model in these cases is not statistically significant. In model 2, R&D relationship activity and the employment growth rate are negatively related ($\beta = -0.215$, $p < 0.05$), and increasing R&D relationship activity and the employment growth rate are positively related ($\beta = 0.196$, $p < 0.05$). Furthermore, the result supports hypothesis 1b and rejects hypothesis 1a. Interestingly, model 2 clearly supports the findings of model 1; thus, the results indicate that R&D relationship activity defines the activity in the relationships on a more generic level. The results of models 3 and 4 support this view, as both the models and the coefficients of the independent variables are insignificant. Model 5 presents results that are similar to those of model 2, but the overall model is not significant, as the F-test value is insignificant at the 10% level.

In model 1, the 'renewable energy technologies' and 'R&D %' control variables are significant at the 5% level. Furthermore, the only control variable that is significant in all models at the 5% level is 'renewable energy technologies'. This variable is positively connected with employment growth in every model. Therefore, firms that are recognised as belonging to this group

Table 17 Regression results and employment growth as the dependent variable (OLS with robust S.E.)

Dependent:	*Employment growth*					
Model:	*1*	*2*	*3*	*4*	*5*	*6*
Active	-0.196+					
Incr. Active	0.328**					
R&D Active		-0.215*			-0.230*	
R&D Incr. Active		0.196*			0.181+	
Manuf. Active			0.021		0.071	
Manuf. Incr. Active			0.077		0.070	
Market. & Distr. Active				-0.049	-0.035	
Market. & Distr. Incr. Active				0.026	0.023	
Age	0.109	0.099	0.097	0.095	0.097	0.097
Employees	-0.011	-0.031	-0.029	-0.025	-0.028	-0.029
Bio	-0.146	-0.051	0.003	0.027	-0.098	0.035
Nano	0.099	0.161	0.069	0.079	0.140	0.085
Environmental technology	0.096	0.005	0.035	0.042	-0.002	0.035
Renewable energy technologies	0.304**	0.344**	0.270*	0.281*	0.325*	0.287*
R&D %	0.369*	0.286+	0.302	0.321	0.280	0.310
Constant	-0.404	-0.294	-0.284	-0.282	-0.301	-0.279
Obs	51	51	51	51	51	51
R^2	0.450	0.405	0.313	0.307	0.414	0.304
F	2.46*	2.2*	1.38	1.46	1.6	1.86
Max VIF	1.76	1.72	1.73	1.77	1.92	1.70
Mean VIF	1.41	1.44	1.42	1.46	1.6	1.41

+Significant at 10%; *Significant at 5%; **Significant at 1%.

evidently have higher employment growth rates than other firms. In models 1 and 2, R&D spending is positively connected with the employment growth rate ($\beta = 0.369$, $p < 0.05$ and $\beta = 0.276$, $p < 0.10$); thus, the results indicate that current R&D spending clearly has a positive effect on revenue growth rates. This finding is similar to the results in the previous sub-section in which the revenue growth rate was used as the dependent variable.

Similar to the previous sub-section, model 6, which does not include any independent variables, is not significant based on the F-test value, and the only significant variable is 'renewable energy technologies'. Additionally, the coefficient of determination is lower than in model 1 (0.304 and 0.450, respectively). Similar to the previous sub-section, the independent variables improve the regression results.

Exports

The third and final regression uses the share of exports as the dependent variable to test hypotheses 2a and 2b. Table 18 shows the results of testing the connections between network activity and the share of exports. Moreover, the models test hypotheses 2a and 2b. Model 1 supports hypothesis 2a. According to the model, relationship activity has a significant and positive connection with the share of exports ($\beta = 0.217$, $p < 0.10$). However, increasing activity is not significant at the 10% level, and the coefficient is 0.000. Thus, hypothesis 2b is not supported, and the results indicate that increasing activity is not connected with the share of exports. The coefficient of determination is not high (0.219). Furthermore, the F-test is significant at the 10% level, and the maximum VIF score is 2.19, which indicates that multicollinearity does not notably affect the results (Hair et al., 2006).

As in the previous regressions, models 2 to 5 analyse whether the effect of active and increasingly active relationships can be specified into a certain theme, such as R&D, manufacturing, or marketing and distribution. The F-test value is significant for models 2 and 5 at the 5% level, and the value for model 3 is significant at the 10% level. Only model 4 is not statistically significant. However, models 2 and 5 are those with the coefficients of the independent variable, which are also significant. In model 2, R&D relationship activity and the share of exports are positively connected ($\beta = 0.291$, $p < 0.05$), and in model 5, the same variable is also positive and significant ($\beta = 0.292$, $p < 0.05$). These findings support hypothesis 2a and particularly emphasise the importance of active R&D relationships.

In model 1, the control variable 'nano' is significant at the 5% level. Furthermore, this variable is significant at the 5% level in model 4 and at the 10% level in model 3. In models 1, 3, and 4, the coefficient attains values between 0.253 and 0.262 and is thus positively connected. The 'revenue' variable is significant at the 10% level in models 1 and 4 and is positively connected ($\beta = 0.046$ and $\beta = 0.051$) with the share of exports. Therefore, larger firms export more than smaller firms.

As in the previous sub-sections, model 6 does not include any independent variable. However, the model is significant at the 10% level based on the F-test value, and the significant control variables are 'revenue' and 'nano'. Additionally, the coefficient of determination is lower than in model 1 (0.182 and 0.219). The difference between models 1 and 6 is smaller than in the previous findings.

Table 18 Regression results and share of exports as the dependent variable (OLS with robust S.E.)

Dependent:	*Exports %*					
Model:	*1*	*2*	*3*	*4*	*5*	*6*
Active	0.217+					
Incr. Active	0.000					
R&D Active		0.291*			0.292*	
R&D Incr. Active		-0.047			-0.025	
Manuf. Active			0.104		0.060	
Manuf. Incr. Active			-0.027		-0.037	
Market. & Distr. Active				0.005	-0.021	
Market. & Distr. Incr. Active				0.038	-0.022	
Age	-0.033	-0.029	-0.043	-0.039	-0.032	-0.047
Revenue	0.046+	0.037	0.044	0.051+	0.031	0.049+
Bio	0.027	0.012	-0.043	-0.038	0.009	-0.020
Nano	0.262*	0.167	0.253+	0.258*	0.167	0.263*
Environmental technology	-0.021	0.067	0.003	0.018	0.061	0.020
Renewable energy technologies	-0.134	-0.178	-0.118	-0.118	-0.174	-0.120
R&D %	0.220	0.250	0.252	0.285	0.228	0.280
Constant	-0.123	-0.008	-0.075	-0.185	0.077	-0.134
Obs	51	51	51	51	51	51
R^2	0.219	0.254	0.197	0.184	0.261	0.182
F	1.82+	3.80*	1.82+	1.51	2.47*	2.03+
Max VIF	2.19	2.21	2.17	2.20	2.54	2.12
Mean VIF	1.49	1.56	1.51	1.56	1.72	1.52

+Significant at 10%; *Significant at 5%; **Significant at 1%.

Regression post-estimation

The post-estimation regression was conducted after the regression analysis. As the regression models use robust Huber-White standard errors (Huber, 1967, White, 1980), the results are not tested for heteroscedasticity.

The variance inflation factors (VIFs) were calculated to test the regression model for multi-collinearity. Hair et al. (2006) suggest that the common VIF cut-off value for large samples is 10, which corresponds to a multiple correlation of 0.95. However, the highest VIF value in this study is 2.82, which is much lower than the limit that was suggested by Hair et al. (2006). In conclusion, multicollinearity does not severely affect this study.

Summary

The results of the regression analysis are summarised in Table 19. The first regression, which used the revenue growth rate as the dependent variable, supported hypothesis 1b but did not support hypothesis 1a. The second regression, which used the employment growth rate as the dependent variable, also supported hypothesis 1b but supported the opposite result than that predicted for hypothesis 1a. In conclusion, hypothesis 1b is supported by both regressions.

In contrast, hypothesis 1a is not supported by the first regression, and the second regression yielded the opposite results. The third regression supported hypothesis 2a but did not support hypothesis 2b.

Table 19 Summary of the results

	Dependent variable		
	Revenue growth	*Employment growth*	*Share of exports*
Hypothesis			
1a. Consistently high activity with network actors has a positive connection with the growth rate of the firm	Not supported	Opposite supported	
1b. Increasingly high activity with network actors has a positive connection the growth rate of the firm	Supported	Supported	
2a. Consistently high activity with network actors has a positive connection with the share of exports			Supported
2b. Increasingly high activity with network actors has a positive connection with the share of export			Not supported

6.4 Robustness

An additional probit regression analysis was conducted to test the robustness of the regression analysis. The aim of this analysis was to test the hypotheses. The probit regression model is a binary choice model in which the value 0 or 1 is assigned to the dependent variable, and the model uses a maximum likelihood method to estimate the results (Greene, 2003). The coefficients of the independent variables are not directly comparable to the results of the OLS regressions (Greene, 2003). However, the sign and significance of the coefficient express the required information for testing the hypotheses. A positive coefficient represents an increase in the predicted probability, which in this analysis can be interpreted as a higher probability of being a high-growth firm.

The dependent variable of the probit regression model is in a binary form. Therefore, the dependent variables that are used in the OLS regression are transformed into a binary form. The analysis is performed using the employment growth rate, the revenue growth rate, and the share of exports as the dependent variables. Despite numerous experimental models, the probit regressions, which used the share of exports as the dependent variable, did not provide statistically significant results; thus, these results are not provided in this paper. The transformations that are required to analyse hypotheses 1a and 1b are performed using a modified version of the OECD-Eurostat (2007) definition of a high-growth firm. According to the definition, a high-growth firm grows an average of at least 20% annually, and the growth rate is measured in employment growth or revenue growth (OECD-Eurostat, 2007). Hence, the dependent variable takes a value of 1 if the annual geometric mean growth rate is 20% or greater and 0 if the growth rate is lower than 20% annually. In addition, the robust standard errors by Huber (1967) and White (1980) are used in the model to address the possible effects of heteroscedasticity, and the significances for the independent variables are reported using one-tailed probabilities that are similar to those used in the OLS regression.

Table 20 Descriptive statistics for the robustness analysis

Variable	*Obs*	*Mean*	*SD*	*Min*	*q25*	*Median*	*q75*	*Max*
Employment growth (bin)	51	0.235	0.428	0	0	0	0	1
Revenue growth (bin)	48	0.354	0.483	0	0	0	1	1

Table 20 shows the descriptive statistics for employment growth and revenue growth in binary form. In total, 35% of the firms are recognised as high-growth firms when measured in revenue growth and 24% when measured in employment growth.

Table 21 shows the pairwise correlations of the employment and revenue growth rates in binary form. Additional correlations were previously described in Table 15. There is a statistically significant correlation between the independent variable 'increasingly active' and the dependent variables of employment growth (0.316) and revenue growth (0.379) both in binary form. In addition, increasing R&D activity is significant, but the correlation is only 0.253.

The results of the probit regressions (in which revenue growth in binary form is the dependent variable) are shown in Table 22. These findings support hypothesis 1b, but they do not support hypothesis 1a. Furthermore, model 1 is the only statistically significant model. In model 1, increasing relationship activity and revenue growth are positively connected ($\beta = 2.990$, $p < 0.01$). This finding supports hypothesis 1b and is consistent with the findings of the OLS regression in sub-section 6.2.1. Relationship activity is not significant at the 10% level; hence, the results do not support hypothesis 1a. Furthermore, this result is consistent with the findings of the OLS regression. In models 2 to 5, none of the independent variables is significant

Table 21 Pairwise correlations for probit regressions

		Employment growth (bin)	*Revenue growth (bin)*
1	Employment growth (bin)		
2	Revenue growth (bin)	0.264+	
3	Active	0.015	0.188
4	Incr. Active	0.316*	0.379**
5	R&D Active	-0.041	-0.021
6	R&D Incr. Active	0.228	0.253+
7	Manuf. Active	0.128	0.114
8	Manuf. Incr. Active	0.159	0.114
9	Market. & Distr. Active	-0.136	0.091
10	Market. & Distr. Incr. Active	-0.014	0.202
11	Age	-0.234+	-0.299*
12	Employees	-0.002	-0.190
13	Revenue	-0.040	-0.006
14	Bio	0.010	0.092
15	Nano	0.073	0.100
16	Environmental technology	0.098	0.308*
17	Renewable energy technologies	0.426**	0.137
18	R&D %	0.252+	0.258+

+Significant at 10%; *Significant at 5%; **Significant at 1%.

at the 10% level. Furthermore, based on the Wald chi^2 test, the hypothesis that the coefficients do not differ from zero cannot be rejected in models 2 to 5.

In model 1, three of the seven control variables are statistically significant. The 'environmental technologies' variable is significant and positively connected with revenue growth ($\beta = 1.844$, $p < 0.01$). The second significant control variable is 'age', which is significant and negatively connected with revenue growth ($\beta = -1.285$, $p < 0.05$). The third variable is 'nano', which is significant and positively connected with revenue growth ($\beta = 1.044$, $p < 0.10$). These results indicate that older firms are less likely to be high-growth firms than younger firms and that firms that specialise in nanotechnologies or environmental technologies are also more likely to be high-growth firms than other firms.

In a comparison of model 1 and model 6 (which includes only the control variables), model 1 has a higher pseudo R^2 value, and the Wald chi^2 test value is also notably higher. These factors demonstrate that the independent variables in model 1 improve the regression results compared with those in model 6. In addition, the accuracy of the models was tested by tabulating the predicted and actual values for revenue growth; thus, a classification matrix was formed (Hair et al., 2006).

Next, employment growth was analysed with the probit regression. The results, which are shown in Table 23, support hypotheses 1b. However, for the hypothesis 1a the opposite is sup-

Table 22 Probit regression for revenue growth

Dependent:	*Revenue growth (bin)*					
Model:	*1*	*2*	*3*	*4*	*5*	*6*
Active	0.300					
Incr. Active	2.990**					
R&D Active		-0.504			-0.553	
R&D Incr. Active		0.695			0.392	
Manuf. Active			0.008		0.021	
Manuf. Incr. Active			0.356		0.469	
Market. & Distr. Active				-0.407	-0.489	
Market. & Distr. Incr. Active				0.491	0.488	
Age	-1.285*	-0.836	-0.813	-0.704	-0.902	-0.755
Revenue	0.232	0.138	0.176	0.205	0.227+	0.161
Bio	0.129	0.495	0.628	0.492	0.451	0.635
Nano	1.044+	0.804	0.564	0.476	0.666	0.572
Environmental technology	1.844**	1.024+	1.187*	1.188*	1.143	1.137*
Renewable energy technologies	-0.586	-0.195	-0.407	-0.299	-0.371	-0.289
R&D %	1.395	1.197	1.414	1.760+	1.581	1.469
Constant	-2.097	-1.194	-1.827	-2.502	-2.358	-1.717
Obs	48	48	48	48	48	48
Pseudo R^2	0.413	0.262	0.241	0.248	0.279	0.234
Wald chi^2	28.47**	12.17	12.71	11.29	17.72	10.89

+Significant at 10%; *Significant at 5%; **Significant at 1%.

ported. The coefficients of model 1 differ from zero at the 5% level of significance, and the pseudo R^2 value is 0.434. Furthermore, increasing relationship activity is significant and positively connected with employment growth ($\beta = 2.294$, $p < 0.01$). However, relationship activity is significant and negatively connected with employment growth ($\beta = -1.429$, $p < 0.05$). Hence, the former finding supports hypothesis 1b, but the latter finding opposites hypothesis 1a. In conclusion, these findings are consistent with the results of the OLS regression in sub-section 6.2.2.

In model 2, R&D relationship activity is negatively connected with revenue growth ($\beta = -0.508$, $p < 0.05$); this result also contradicts hypothesis 1a. In model 4, marketing and distribution relationship activity is negatively connected with employment growth ($\beta = -1.256$, $p < 0.05$). These two findings support the opposite of hypothesis 1a, as the coefficients in both models differ from zero (at the 10% level in model 2 and at the 5% level in model 4). However, the pseudo R^2 value is low (0.291) in the case of model 4. Model 5 provides results that are partially consistent with the previous models, as increasing R&D relationship activity is positively connected with employment growth ($\beta = 1.466$, $p < 0.01$), and R&D relationship activity is negatively connected with employment growth ($\beta = -1.480$, $p < 0.01$). By contrast, manufacturing relationship activity is positively connected with employment growth ($\beta = 0.895$, $p < 0.05$). Hence, model 5 supports hypothesis 1b, whereas hypothesis 1a is supported by manufacturing relationship activity but not supported by R&D relationship activity opposites it.

Table 23 Probit regression for employment growth

Dependent:	*Employment growth (bin)*					
Model:	*1*	*2*	*3*	*4*	*5*	*6*
Active	-1.492*					
Incr. Active	2.294**					
R&D Active		-1.458*			-1.480**	
R&D Incr. Active		1.444**			1.466**	
Manuf. Active			0.260		0.895*	
Manuf. Incr. Active			0.192		0.390	
Market. & Distr. Active				-1.256*	-0.556	
Market. & Distr. Incr. Active				-0.270	0.075	
Age	-0.040	-0.197	-0.190	-0.351	-0.222	-0.18
Employees	0.190	-0.095	0.011	0.048	-0.065	0.017
Bio	-1.199+	-0.252	0.070	0.148	-0.597	0.141
Nano	1.389*	1.451*	0.566	0.871*	1.412*	0.609
Environmental technology	0.179	-0.717	-0.365	-0.085	-0.975+	-0.28
Renewable energy technologies	2.435**	2.707**	1.485*	1.575**	2.617**	1.522**
R&D %	1.184	0.279	0.599	0.724	0.264	0.678
Constant	-3.594**	-2.027	-1.500	-1.220	-2.110	-1.519
Obs	51	51	51	51	51	51
Pseudo R^2	0.434	0.393	0.248	0.291	0.426	0.243
Wald chi^2	17.71*	17.44+	13.53	18.28*	22.88*	13.53*

+Significant at 10%; *Significant at 5%; **Significant at 1%.

In model 1, the coefficients of three control variables are statistically significant. The 'renewable energy technologies' variable is positively connected with revenue growth and significant at the 1% level. The second significant control variable is 'nano', which is positively connected with revenue growth and significant at the 5% level. The third variable is 'bio', which is negatively connected with employment growth and significant at the 10% level. These results indicate that firms that specialise in nanotechnologies or renewable energy technologies are more likely to be high-growth firms than other firms, and firms that specialise in biotechnologies are less likely to be high-growth firms.

In comparisons of model 1 and model 6 (which includes only control variables), model 1 has a higher pseudo R^2 value, and the Wald chi^2 test value is also higher. These factors demonstrate that the independent variables (especially those in model 1) improve the regression results compared with model 6. In addition, the accuracy of the models was tested by tabulating the predicted and actual values for employment growth and thus forming a classification matrix (Hair et al., 2006).

In conclusion, the results in this section generally support the findings of the OLS regression. Hypothesis 1b is widely supported, as increasing relationship activity was positively and significantly connected with the growth measures in question. However, hypothesis 1a was opposed when the dependent variable was employment related. Hypotheses 2a and 2b could not be tested with the probit regression model because the results were not statistically significant with any of the tested threshold values. This finding could result from the distribution of the share of exports presented in Figure 14.

6.5 Summary of the results

To conclude this chapter, Table 24 summarises the results of this study. The results are formed by combining the results of both the OLS regression and the probit regressions.

Table 24 Summary of the results

	Dependent variable		
	Revenue growth	*Employment growth*	*Share of exports*
Hypothesis			
1a. Consistently high activity with network actors has a positive connection with the growth rate of the firm	Unsupported	Opposite supported	
1b. Increasingly high activity with network actors has a positive connection the growth rate of the firm	Supported	Supported	
2a. Consistently high activity with network actors has a positive connection with the internationalisation of the firm			Partially supported
2b. Increasingly high activity with network actors has a positive connection with the internationalisation of the firm			Unsupported

In conclusion, the results indicate that hypothesis 1b is the only fully supported hypothesis. In contrast, hypothesis 2a is partially supported, hypothesis 2b is unsupported, and the results support a claim that is the opposite of hypothesis 1a.

7 Discussion and conclusions

7.1 Discussion

The aim of this study was to investigate how network relationship activity influences the growth and internationalisation of technology-based firms in emerging technology areas. The study demonstrated a positive connection between the creation of new active relationships and firm growth. This result confirms the findings of Coviello (2006), Jack et al. (2008), and Prashantham and Dhanaraj (2010), who suggest that there is a positive connection between the development of new, relevant connections and firm growth.

Moreover, the results indicate that the importance of an actor group depends on the relationship type. Large customers both in Finland and abroad are the two most important actor groups in R&D relationships, whereas suppliers are the most important actor group in manufacturing relationships, and distributors are the most prominent actor group in marketing and distribution relationships. The surprising result is the relative unimportance of universities and research institutions in R&D relationships, especially in comparisons of the importance of Finnish and foreign actor groups in which foreign actors have considerably lower importance. These findings provoke questions because the firms that are included in this study are exploiting emerging technologies and are growth oriented; it would seem logical to assume that these firms are cooperating with the experts in their field.

In addition, the current study found support for the hypothesis that the creation of new active relationships is positively connected with firm growth. This finding is consistent with that of Watson (2007), who observed a positive connection between sales growth and networking. Furthermore, both the OLS and probit regressions indicate that increasing R&D relationship activity and employment growth rates are positively connected. Moreover, the analysis in section 6.1 shows that customers are the most important sources of information during the last three years and that customers both in Finland and abroad are the most beneficial actor group in the formation of new relationships. When the above finding is linked to the knowledge that the most important actor groups in R&D relationships are currently large customers both in Finland and abroad, the importance of good relationships with large customers is evident. This finding is supported by earlier studies, such as those of von Hippel (1978) and Baldwin et al. (2006), who recognised customers as the central sources of information and innovations.

Another important finding supports the assumption that the importance of a network relationship is connected with the strength of the tie. Moreover, the study recognises customers as the most important sources of information and new contacts. The above result and the knowledge that large customers are observed to be the most important actor group in R&D relationships addresses the connection between information sharing and strong ties.

Nevertheless, the results of the current study do not support several previous findings by Coviello (2006). In her study, Coviello (2006) claims that strong-tie relationships maintain their

importance over a long time period. This study does not support the claim of Coviello (2006) when the connection is tested against the revenue growth of a firm, and strong-tie relationships show a negative connection when the dependent variable is related to employment. Further analysis suggests that the negative connection can be associated with R&D relationships and marketing and distribution relationships. Increasing R&D relationship activity, which has a significant positive connection with the growth rate, renders this finding interesting.

Contrary to the findings of the negative connection between long-term relationships and firm growth, this study found support for the hypotheses that there is a positive connection between these relationships and the share of exports. In particular, the connection between active R&D relationships and the share of exports is significantly positive. In this case, the importance of foreign actors in the formation of new foreign relationships additionally supports the hypothesis that existing strong ties are beneficial in the internationalisation of operations. The analysis shows that the importance of foreign customers and foreign distributors and retailers in the formation of new co-operational relationships is evident. However, the study did not find support for the hypothesis regarding the connection between increasing relationship activity and the share of exports. The reason for this result is not clear, but it could be related to the measurement, which does not account for the change in internationalisation; on the contrary, the instrument measures previous success.

The analysis of the important information sources found that public research institutes and universities are not among the most important actors, although pre-existing studies have claimed their importance in innovation networks (Pittaway et al., 2004, Ferrary and Granovetter, 2009). This result suggests that the flow of information between these organisations and the firms is not at an optimal level and that the findings of research organisations are not commercialised as intended. However, scientific journals and trade or technical publications are the third most important sources of information. This inconsistency may result from the primary interests of the firms in results and less interest in what is currently occurring in their field or what topics leading scholars are currently researching.

Finally, one implication of this study is the importance of customers and the sources within firms. This implication suggests that internal R&D activities are at a high level. The contrast between the importance of internal and external R&D sources (e.g., universities and research institutions) is noteworthy. The findings suggest that the internal research of several firms is isolated from external research operations.

7.2 Limitations of the study

Generalisability

This study has several limitations that should be recognised; thus, this section discusses generalisability, methodology, and the data. Issues regarding the generalisability of this study arise from its scope, as the subjects are Finnish or originally Finnish-owned firms; hence, the review is geographically limited. This limitation may influence the generalisability of the results, as country-specific and cultural issues may affect networking activity with different actors. For instance, previous studies have claimed that the degree of reliance on strong-tie relationships depends on the cultural context (Bolton et al., 1994, Nooteboom, 2000).

The scope also restricted the study to exploring the networks of firms that exploit at least one of the three specific technologies. These technologies were nanotechnologies, environmental technologies, and renewable energy technologies. The technology limitations of this study combined with the country limitation limited the possible sample size to 120 firms. A larger sample size would have enhanced the reliability and generalisability of the statistical analysis that was used in the regression analysis. However, the response rate of the survey was 43%, and the representativeness of this study is thus excellent. Furthermore, the importance of and interest in these technology sectors counterweight the possible limitations that the sample size imposes to a certain degree.

The final issue is a possible selection bias that could have arisen from identifying a quite large number of firms that operate in the investigated technology sectors because firms with no connections to the Finnish Centre of Expertise Programmes (Oske) or to the Finnish Funding Agency for Technology and Innovation (Tekes) may have been identified, as Oske and Tekes were the two most important information sources when the potential interviewees were recognised.

Methodology

This research used various methods to enhance the reliability of the study. Of the two most important methods, the first method employed both revenue and employment growth to measure the growth rate of the firms. The second method involved performing the probit regressions in addition to the OLS regressions.

The use of both revenue and employment is justified, as the revenue growth data are available from only 48 of 53 firms, and the employment growth data from only 52 of 53 firms. Furthermore, during 2008 and 2009, the Finnish economy suffered a downturn, which affected the revenues of the firms than more adversely employment (Rautio and Kivimäki, 2010). This effect may have skewed the initial state of the analysis when only the revenue growth rate was used. In addition, during the data collection, it was noted that some firms had not added their revenues from licenses as revenue in their financial statements; this omission may have skewed the revenue growth rates. In addition, based on the financial reports, some firms report only their gross margins and do not report their revenues at all. With the use of both revenue and employment growth measures in parallel, the credibility of the study increased.

The control variables, which were created to measure the connection between a firm and a technology, may have limitations because they were formed based on the personal views of the interviewees. Despite the possible weaknesses of this approach, it was viewed as the most reliable method because no objective measures were available. Second, these control variables measure two different connections between firms and technologies. These variables measure the usage of a technology and the usage of a firm's products in certain technology sectors. For instance, one firm can use nanotechnology in their products, whereas another firm may produce state-of-the-art components that are used exclusively in wind turbines, which represent renewable energy technologies in this study. In addition, the distinction between environmental technologies and renewable energy technologies is unclear. This issue was perceived when the variables were formed; hence, the variables are not exclusionary.

Finally, this study aspired to pre-empt possible causality issues by concentrating on different actor groups to create the activity measures. Consequently, the increasing number of relation-

ships with actors within the same group does not affect the activity measures if the importance level remains stable. Thus, causality concerns are reconciled in this study.

Data

This study includes data from two sources. First, data were collected from the survey; second, financial data were obtained from a database that was compiled by Suomen Asiakastieto Oy. However, the financial data, specifically the revenue and employee information, from the external database contained gaps, as the newest data were not available in the database. Hence, the data that were necessary to fill the gaps were collected from the interviewees. These data may be less reliable than the data from the databases because the interviewees recalled the data from memory. This same observation is valid for the share of exports and the share of R&D, as this information was requested in the survey. The compilation of two data sets created the potential for errors and mistakes, which were minimised by cross-checking the combined data set.

The data in the matrix, which was created to analyse the networking activity of the firms, are based on the opinions of the interviewees; thus, the data are vulnerable to misinterpretation, as different interviewees may have had different interpretations of the scale that was used to measure the activity. This risk is minimised by using only the highest importance level in the key independent variables, 'active' and 'increasingly active'. The bias may be more evident in the variables that study particular relationship types, as the second highest importance level is also observed in these variables.

Finally, the study could have omitted some independent and control variables. For instance, the regression analysis considers only the importance of the relationships, and the quantities are not observed; thus, this possible omission could have biased the results. Furthermore, the number of different actors included in the activity measures is limited. Adding the quantities into the model would have provoked causality issues. However, the models were created to be representative, and the number of variables was minimised to decrease multicollinearity. The representative nature of the models is also related to time issues, as the length of the survey was a compromise between research needs and the willingness of the interviewees to respond.

7.3 Implications and further research

Managerial implications

This study offers perspectives on why networking is essential for managers in general and particularly for managers of Finnish firms that operate in emerging technology areas. The findings encourage managers to engage in active networking with different actors within and outside of existing networks and especially with those who are relevant to the business in which a manager and a firm operate. The results strongly support the necessity for managers to create new active co-operational relationships. The reason for this recommendation is twofold. First, the evolution of a firm creates the need for new contacts and ties. This need corresponds to a change in the situation of a firm, which can be regarded as, for instance, a need for new contacts in a new market or a change in the technology that is exploited by the firm. Second, managers must create new social capital to replace the natural depreciation of the existing social capital.

However, the suggestion to actively form new ties does not indicate that managers should aim to form a maximum number of new ties without any direction. Rather, managers should focus their networking activity on actors with whom relationships can be mutually beneficial. Discussions with network partners to form a vision for the future of a business are useful strategies for recognising future networking needs. Over time, a relationship can deepen and become a strong tie. Nevertheless, managers should also recognise the potential complications of an over-embedded network; therefore, finding a balance between strong and weak ties is important.

The results show that customers, scientific journals and trade publications, and conferences and trade fairs are the most important information sources. However, the lack of importance of research institutes and universities as information sources is concerning, especially given that access to new information is one of the key benefits of network relationships for managers. Nevertheless, the findings of this study offer an interesting contrast to the literature, which suggests that firms benefit from forming new and stronger ties with the institutions mentioned above.

Additionally, managers who are spanning networks have an important role in information brokering because these managers can access otherwise unavailable information by bridging unconnected networks and thus providing a channel for information flow, which is then controlled by these spanners. Therefore, according to this study, firms that work closely with universities and research institutes may be in a better position than their counterparts, particularly because the study showed that relationships with these actors are less developed.

Research implications

The findings of this study contribute to network research by adding a new approach to studying networks; previous studies have primarily featured case studies that have analysed the networks of two to five firms or longitudinal studies that have utilised external data sources, such as patent and acquisition databases, to define the evolution of network ties. The networks in this study were defined by the firm managers, and the information that was collected regarding the evolution of the networks was then connected with firm performance. This new approach provided interesting results, as the study found a statistically significant positive connection between the growth rate of the firms and the creation of new strong-tie network relationships.

The connection between strong, long-term co-operational relationships and firm growth rates was found to be negative in the analysis and thus contrasts with the results of earlier studies, such as the work of Coviello (2006). This finding indicates that network relationships should evolve in connection with the evolution of the needs of a firm.

The results also indicate a low level of high-importance network relationships with research organisations. This result is contrary to the views of earlier studies, which have asserted the importance of those actors (e.g., Powell et al. (2005), Ferrary and Granovetter (2009). However, the importance of R&D relationships with customers is evident. Furthermore, customers are the most important information source and the most important actor group that assists in brokering new co-operational relationships. These findings suggest that the interviewees regard customer relationships as important; indeed, these firms appear to be highly customer-

oriented. Nonetheless, the results suggest that relationships with research organisations are unimportant to these firms and that such ties are more likely to be arm's-length ties. In addition, most of the interviewees appear to lack channels that provide access to the results of the most current Finnish scientific research.

The connection between the internationalisation of firms and activity in co-operational relationships is less evident, but the results clearly support the importance of network ties. However, the results also support the claim that foreign network connections are beneficial for forming new connections and that customer, distributor, and retailer connections have particularly benefitted foreign operations.

From a research perspective, the findings of this study support the view that network relationships require further research. In particular, the connection between firm performance or firm success and networking would be an important and interesting research topic. This study has offered statistical evidence of a positive connection in the studied environment. However, an interesting research frame would be a larger and more homogeneous sample combined with a more extensive actor distribution to be examined over a longer period by periodically studying current networks.

A second future research topic is the relatively low importance of universities and especially research institutions in research and development relationships. Furthermore, these organisations serve as relatively unimportant sources of information compared with clients and scientific journals or trade publications. Both findings create new questions that should be studied to identify the issues that affect these phenomena and the consequences, especially because the ability of the Finnish innovation system to create economic activity that is comparable to investments in scientific research is called into question (Tahvanainen and Nikulainen, 2011).

In conclusion, this study has produced new information and contributed to the existing body of literature by describing the connection between networking and firm performance. The positive connection that was found to exist between increasing activity in co-operational relationships and the growth rates of firms supports earlier views that have claimed that networking is important for high-growth firms. However, the results of this research should be further studied to better understand the forces and concepts behind this phenomenon.

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Appendix A: The survey

Interviewer:

Firm:

Register number:

Hello, my name is [interviewer] and I am calling from the Research Institute of Finnish Economy. Am I disturbing you?

We are currently studying growing technology companies and their renewal and co-operation patterns at ETLA. Related to the research we interview business executives in different areas of business as widely as possible.

The interview lasts approximately 40 minutes. Is the interview convenient now or later?

The answers are confidential and the collected information about companies or individuals will not be published in any form.

Interviewee:

Phone number:

Switchboard:

Date:

Time:

1. The survey has three parts. At first we ask some basic information related to your firm.

1.1. Which of the following is your main source of income?

- *From enterprises* *[_]*
- *From consumers* *[_]*
- *From public sector* *[_]*
- *DK* *[_]*

1.2. What is the main position of your firm in the supply chain?

- *Subcontractor (Products / services into the customer's supply)* *[_]*
- *System provider (Provides modules to main contractors)* *[_]*
- *Main contractor (Seller and designer of the final product / service)* *[_]*
- *DK* *[_]*

1.3. Does the firm operate or has it operated in an incubator or in a science park?

- *Yes* *[_]*
- *Yes, before* *[_]*
- *No* *[_]*

1.4. When the firm is established?

- *Year: ____*

1.5. When did the firm sell its first product or service to a customer?

- *Year:____*

1.6. Next shortly about the establishment of the firm...

	Yes	No
– *Is the firm a spinoff of other firm?*	*[_]*	*[_]*
– *Is the firm based on the research or operation of your previous firm?*	*[_]*	*[_]*
– *Is the firm based on the research or operation of other firm?*	*[_]*	*[_]*

1.7. Is the firm a part of an enterprise group?

– *Yes* *[_]*
– *No* *[_]*
– *DK* *[_]*

1.8. If yes, where the parent is headquartered?

– *In Finland* *[_]*
– *Abroad, where:_____* *[_]*
– *DK* *[_]*

1.9. Which of the following describes best the firm?

– *Operates only in Finnish market* *[_]*
--> Jump to 1.10.
– *Finland based exporter* *[_]*
– *Multinational firm* *[_]*

1.9.1. When did you start exporting?

– *Year: ____*

1.9.2. When did you open your first office abroad?

– *Year: ____*

1.9.3. How large part of the revenue comes from exports exported from Finland?

– *_____%*

1.9.4. What is the proportion of services of your total exports?

– *_____%*

1.10. When discussing the role of services in the business. What proportion of the total revenue is related to the services?

– *_____%*

1.11. Next, we ask about the business model. In your opinion do your firm have a number of different business models related to different products or services?

– *Yes* *[_]*
– *No* *[_]*

How would you describe your (first / second ...) business model?

How would you describe your (first / second ...) business model?

	What your company is doing by yourself											
	Research and development			Manufacturing		Reselling		Marketing		Consulting	Else?	% of
Business model	For own needs	As service	Licensing to others	Self	Outsourced	Self	Outsourced	Self	Outsourced			Revenue
1												
2												
3												
4												
5												

1.12. Do you have a client which accounts for sales of more than a third?

– *Yes* *[_]*
– *No* *[_]*
– *DK* *[_]*

If yes, is it a part of the same group?

– *Yes* *[_]*

1.13. Do you have a subcontractor which is difficult to substitute and accounts for purchases of more than a third?

– *Yes* *[_]*
– *No* *[_]*
– *DK* *[_]*

If yes, is it a part of the same group?

– *Yes* *[_]*

2. Next, we cover the firm's interorganisational networks

2.1. Next we will discuss how your interorganisational network is changed over time with different actors. Please, evaluate the significance of the following actors for the development of your business in three different areas using a four-value scale, where 1 - Not at all important and 4 - Very important

Example: **How important the R&D co-operation with the large customers is at the moment?**

	R&D					
	at the moment		about 3 year ago		after 3 years	
	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign
Large customers. Employs over 50 people						
Small customers						
Competitors						
Distributors						
Suppliers						
Universities						
Research Institutes						

Example: **How important the manufacturing co-operation with the large customers is at the moment?**

	manufacturing					
	at the moment		about 3 year ago		after 3 years	
	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign
Large customers. Employs over 50 people						
Small customers						
Competitors						
Distributors						
Suppliers						
Universities						
Research Institutes						

Example: **How important the marketing and distribution co-operation with the large customers is at the moment?**

	marketing and distribution					
	at the moment		about 3 year ago		after 3 years	
	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign
Large customers. Employs over 50 people						
Small customers						
Competitors						
Distributors						
Suppliers						
Universities						
Research Institutes						

Could you give an assessment of the number of the above-mentioned actors?

Example: **How many big co-operational customers you have currently on the domestic market?**

	How many?					
	at the moment		about 3 year ago		after 3 years	
	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign
Large customers. Employs over 50 people						
Small customers						
Competitors						
Distributors						
Suppliers						
Universities						
Research Institutes						

2.2. Next, we enquire how you are creating new co-operation relationships

2.2.1. During the last three years ... do you have benefited significantly from existing relationships with the following actors when creating new co-operational relationships?

	Domestic	Foreign
Customers		
Competitors		
Distributors and retailers		
Suppliers		
Science Parks, Incubators and Centres of Collaboration		
Business networks and clusters		
Universities		
Public research institutions		
Consultants		
ELY/TE-centres		
Venture capitalists, angels and private equity investors		
Public funders		
Relatives and close friends		

2.2.2. Is the role of any of the above or any other actor's role especially emphasised when creating relationships? Which?

2.2.3. When creating relationships with actors, is the importance of an actor or actors increased or decreased significantly over the last three years? Whose?

2.2.4. Are you expecting that the importance of some of the above mentioned actors increasing or decreasing while creating new relationships over the next three years?

2.2.5. Has the importance of foreign actors being emphasised when creating new relationships during the last three years?

- *Yes* *[_]*
- *No* *[_]*
- *DK* *[_]*

2.2.6. During the last three years how important the following sources of information have been when creating the big picture of future in your industry? 1 - Not at all important and 4 - Very important

- *Within your firm or enterprise group* *[__]*
- *Suppliers of equipment, materials, components, or software* *[__]*
- *Clients or customers* *[__]*
- *Competitors or other companies in your business* *[__]*
- *Consultants, commercial labs, or private R&D institutes [__]*
- *Universities or other higher education institutions* *[__]*
- *Government or public research institutes* *[__]*
- *Conferences, trade fairs, exhibitions* *[__]*
- *Scientific journals and trade/technical publications* *[__]*
- *Professional and industry associations* *[__]*

3. Next we would inquire more of your firm's innovation process

3.1. First some background information

3.1.1. Do you practice R&D?

- *Yes* *[_]*
- *Yes as service* *[_]*
- *No* *[_]*

3.1.2. If yes, how much of the net sales the research and development spending accounted for in 2010? (%)

___%

3.1.3. If yes, the firm's research and development employees at the end of 2010?

___people

3.1.4. If yes, how many of those worked abroad?

___people

3.1.5. If yes, how much of the research and development activities has been outsourced to universities or other research and development service providers

___%

3.2. During the last three years, did your firm introduce

	Yes	No
– *New or significantly improved producing goods?*	*[_]*	*[_]*
– *New or significantly improved services?*	*[_]*	*[_]*

3.3. Were any of your innovations during the last three years...

	Yes	No	DK
– *A first in Finland*	*[_]*	*[_]*	*[_]*
– *A first in Europe*	*[_]*	*[_]*	*[_]*
– *A world first*	*[_]*	*[_]*	*[_]*

3.4. Cyclicality of technologies and innovations

3.4.1. How long the average development time of emerging technologies is?

___years

3.4.2. How challenging is it to anticipate the technological advancements?

1 - Very easy	2	3	4 - Very challenging
[_]	[_]	[_]	[_]

4. The last section briefly discusses the firm's operating environment

4.1. Home market: Can you assess how significant the domestic market is for your firm as a springboard for international expansion? On a scale of 1 - Not at all important and 4 - Very important, 0 – DK

___

4.2. Do you think that there is enough supporting industry in Finland?

- *Yes*
- *No*

If no, who could be?

5. Is your firm's goal to grow more than 50% in terms of employees or turnover over the next two years?

- *Yes* [ ]
- *No* [ ]
- *DK* [ ]

6. Finally, I ask you to assess the extent to which you are applying the following technologies? On a scale of 1 - none and 4 - extensively

- *Biotechnology* [__]
- *Nanotechnology* [__]
- *Environmental technology* [__]
- *Renewable energy technologies* [__]

- *If you do not apply any of the above-mentioned technologies, then what technologies are you applying in your opinion?*

If environmental technology or alternatively renewable energy technologies are bigger than two (2) ask specifying questions:

6.1. Subdivision

Environmental technologies	Yes
– *Air pollution control*	*[_]*
– *Water pollution control*	*[_]*
– *Solid waste management*	*[_]*
Renewable energy technologies	
– *Solar*	*[_]*
– *Biomass*	*[_]*
– *Wind*	*[_]*
– *Ocean*	*[_]*
– *Geothermal*	*[_]*
– *Hydropower*	*[_]*
– *Other?*	*[_]*

7. How do you see the future of your firm and industry and, furthermore, the most important challenges?

Thank you for your co-operation. A study associated with the theme will be published by the end of the year. We will gladly send you the report electronically if you wish.

Email:

Aikaisemmin ilmestynyt ETLAn Keskusteluaiheita-sarjassa

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