Management of innovation in networks and alliances

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Management of innovation in networks and alliances

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Chapter 1

Introduction

1.1 Challenges to be addressed

To remain competitive in a world of global competition a company has to adapt to changing situations at an increasing speed. Product life cycles are shortening and require companies to innovate in ever shorter time intervals. *The pressure to do more with less inexorably pushes […] companies to focus on their unique, hard to imitate and distinctive core competencies, continually nurturing and enhancing them, while abandoning those activities in which they do not possess distinctive competencies* (Omta and Van Rossum, 1999, see also Hamel and Heene, 1994, Hamel, 1996, Sanchez et al., 1996). At one point in time the innovation potential of a single company, based on its resources and core competencies, might be sufficient to face the competition. However, if a transformation of the company's resources and capabilities is needed to face the fast changing business competition this might take too much time, and the new capabilities could be outdated already at the moment the change is achieved. In a network also resources of other network members might become accessible, which could speed up the innovation process. By combining the resources and core competencies of different organizations the race might be won. Therefore *the capability of building and maintaining inter-organizational network relationships, such as joint ventures, license agreements, supplier customer partnerships and strategic alliances is increasingly viewed as key to sustained competitive advantage* (Omta and Van Rossum, 1999). This book discusses the important topic of the management of innovation in such inter-organizational networks by focusing on the management of innovation both at the network level and at the strategic alliance level of the individual company.

Several empirical studies in high-tech (Christensen et al., 2005, Fetterhoff and Voelkel, 2006, Dittrich and Duysters, 2007) and medium and low-tech industries (Batterink, 2009) suggest that applying an open innovation business model, (Chesbrough, 2003, 2006, 2008) involving other organizations in the innovation process, may provide a bigger innovation potential compared to closed (in-house) innovation models (Batterink, 2009, Baum et al., 2000). Chesbrough et al. (2008) define open innovation as *the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of knowledge respectively*. To create value and to capture it employing an appropriate open business model is key according to the open innovation paradigm (Chesbrough, 2003, 2006). Also a number of empirical studies positively link the use of inter-organizational cooperation to the innovation performance of a firm (e.g. Miotti and Sachwald, 2003, Negassi, 2004, Sampson, 2007, Stuart, 2000).

But there is also a downside to the new interconnectivity of firms. Companies fear that they are becoming increasingly vulnerable due to dependencies on external innovation sources which might diminish their competitive advantage (Millson et al., 1996, Jonash, 1996). Further connecting to one or a limited number of network(s) or alliance partner(s) may exclude access to others. Another vulnerability concerns unwanted knowledge spillover that could be used competitively against the firm the knowledge originally stems from. There are also coordination costs related to the engagement in networks and alliances, obliging managers to calculate the costs against the benefits. In conclusion, there are a lot of management challenges deriving from inter-organizational cooperation (Gulati and Singh, 1998, Omta and Van Rossum, 1999, Nooteboom, 2002).

The list of possible inter-organizational collaboration problems is long. Critical issues that play a role in an inter-organizational cooperation range from: Which company is contributing what, how high are the coordination costs, is the exchange of knowledge symmetric enough (problem of outlearning the partner, Hamel, 1991); and which company is benefiting most from the results (Farr and Fischer, 1992). The conclusion may be derived that the open innovation business model is not a self-evident choice. Instead the decision boils down to the question: *Do the additional benefits from using an open innovation model exceed the additional costs?* Based on the number of partners involved and the interdependencies between the partners, a balance of contributions and results should be aimed for. To achieve this balance, different governance mechanisms are employed. In contrast to the occurrence of inter-organizational collaboration problems, the governance mechanisms for controlling them and especially the interplay between different governance mechanisms are far less researched. This leads to the main research question and the main objective of this book.

Main research question: How to address the organizational challenges stemming from innovation in inter-organizational settings by focusing on innovation within networks, e.g. a cluster of companies, as well as in specific innovation alliances?

Main objective: To analyze different governance mechanisms that can be used by stakeholders, such as alliance managers, cluster coordinators and policy makers, to improve innovation alliance and network performance. The findings of this thesis aim at deriving recommendations to be applied at the international, national and regional network levels as well as at the innovation alliance level.

This book can be used by companies to improve the management of their inter-organizational research and development (R&D) project management. Cluster coordinators can use it to improve their cluster member support, and to enhance the performance of their network. Policy-makers can increase their insight into the way in which inter-organizational (co-innovation) partnerships can be organized and managed and how they can be supported on the network level. From the theoretical point of view, the study adds to the existing literature about innovation management by specifying governance mechanisms on the cluster and alliance level which can enhance innovation performance in interfirm/co-innovation partnerships.

1.2 Management of innovation

Innovation involves the conversion of new knowledge into a new product, process or service and putting this new product, process or service into use (Johnson et al., 2008). Teece (1996) further distinguishes between autonomous and systemic innovations, the difference being whether the innovation stands alone or requires adjustments of the system around it. Stimulating innovation stands high on national and supranational political agendas (e.g. Commission, 2011) and across industries, firms use it increasingly to gain competitive advantage (Hult et al., 2004, Christensen et al., 1998). More than half of the R&D efforts within the EU, in terms of the number of researchers and the R&D investments, are company based (Commission, 2011). The importance of innovation is also recognized by the business community, as can be seen from the 2005 Innovation Survey initiated by the American Management Association (AMA). In the survey 1,396 executives in large multinational companies were addressed. More than 90% of the respondents referred to innovation as important to extremely important for their company's long-term survival, with over 95% considering that this would still be the case in ten years' time (Jamrog and Bear, 2006). Although the importance of innovation is clearly recognized, the achievements of the many innovation efforts are not satisfying (Jamrog and Bear, 2006). Innovating is connected to high failure rates. When it comes to innovation, companies are in almost 50% of the innovation projects confronted with unsatisfying profitability and only half of the new products reach the market within the foreseen time frame (Cooper and Edgett, 2009). This raises the question: Why is it so hard to achieve and implement a successful innovation?

One of the factors underlying the high innovation failure rate is the uncertainty related to the search for new knowledge and the development of new products and processes. According to Thompson (1967) the source of internal uncertainties is the interdependence of components. *Models that depict innovation as a smooth, well-behaved linear process badly misspecify the nature and direction of the causal factors at work. Innovation is complex, uncertain, somewhat disorderly, and subject to changes of many sorts* (Kline and Rosenberg, 1986). According to Omta and De Leeuw (1997) *it is not primarily the uncertainty of the research process itself, but the uncertainty in relation to the task environment that counts*. This uncertainty limits the extent to which an innovation process can be planned beforehand, and raises the question to what extent it should be planned (Janszen, 2000, Cheng and Van de Ven, 1996, Holmstrom, 1989). That the innovation process with all its interdependent components needs to be coordinated is however beyond question and constitutes a specific managerial challenge.

The innovation process can be divided into exploration and exploitation components (Holland, 1975, March, 1991, Li et al., 2008). Exploitation is concerned with the refinement and extension of existing technologies (Lavie and Rosenkopf, 2006) and exploration is rooted in the extensive search for potential new knowledge (March, 1991). Soosay and Hyland (2008) see exploration as a type of learning in terms of new knowledge, skills and processes, while Nooteboom et al. (2007) see it as the experimentation with new alternatives. For companies to engage in exploration and exploitation is crucial to create and keep the ability of implementing innovations. However, to engage in exploration and exploitation activities autonomously might exceed the firm's resources. To overcome these resource constraints Lavie (2006) suggests trying to achieve competitive advantage by involving other organizations in the innovation process, as an interconnected system. By doing so, the innovation process moves from closed (in-house) to open innovation. (Chesbrough et al., 2008) refer to open innovation as *the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of knowledge respectively*.

1.2.1 Innovation at network level

Following Folkerts and de Jong (2013), three inter-organizational network types can be distinguished. Chain networks concern the cooperation of companies along the supply chain.

In contrast, horizontal cooperation between similar types of companies is termed an industry (company) network, while in case this network also contains companies that are really different, the term diagonal network is applied. As has been said before, innovations are increasingly conducted in inter-organizational networks (Coombs et al., 2003, Powell et al., 1996). *Firms increasingly become part of networks, in which resources, knowledge and information circulate rapidly and at low cost, and which strongly rely on collaborations and partnerships (Chiesa and Manzini, 1998)*. Knowledge diversity within a network is beneficial because it generates positive externalities to multiple agents through knowledge spillovers, increasing opportunities for innovation (Feldman and Audretsch, 1999, Kogut, 2000). *To be part of a network, and to be able to effectively exploit the information that circulates in the network, has become even more valuable than being able to generate new knowledge autonomously (Gambardella, 1992).* Quinn (2000) highlights that in order to compete, cooperation within a network of partners is becoming essential (see also Ritter and Gemünden, 2003), while Stabell and Fjeldstad (1998) conclude that the value of the network increases with its expected size. Interacting with external partners enables a firm to access new knowledge, while network connections seem to promote innovative performance (Caloghirou et al., 2004). Granovetter (1973) stresses in terms of network functionality also especially the importance of weak ties, while Faems et al. (2005) highlight the importance of diversity in external relationships to stimulate innovation. Network connections, next to inter-company connections, also concern linkages between companies and knowledge institutions as recent studies show a widespread use of university-industry partnerships (Schartinger et al., 2002, D'Este and Patel, 2007, Meyer-Krahmer and Schmoch, 1998, Perkmann and Walsh, 2007). In case also a governmental body is involved in such a university-industry partnership, the term triple helix cooperation is used. In contrast, one speaks of sectorial cooperation in the case of precompetitive cooperation between similar companies only (Sluijter et al., 2012).

Innovation within networks is extensive because of the sustained interaction between institutions and commercial organizations of different size, capabilities and expertise (Omta and Van Rossum, 1999). A number of authors highlight the specific advantages of innovating within networks. Silicon Valley, as famous example of an innovation network, is claimed to enhance information exchange and to allow new contacts and to build relationships between network members (Saxenian, 1990) and is used as standard to compare other high-tech networks against (e.g. Bresnahan and Gambardella, 2004). Bahrami and Evans (2000) conclude that the achievement of flexibility through a dynamic re-combination of resources can take place both within the formal boundaries of a firm and across those boundaries. Networks further allow companies to complement their competencies and capabilities with those of the other network members. A good example is the cooperation of small and medium sized enterprises (SMEs) in the biotechnology sector and big pharmaceutical and chemical companies that partner with each other to overcome their respective disadvantages by benefitting from their complementary competencies and resources (Rothaermel, 2001, Nooteboom, 1994).

1.2.2 Innovation at alliance level

Gulati (1998) defines a strategic alliance as *voluntary arrangements between firms involving exchange, sharing, or co-development of products, technologies or services (Gulati, 1998).* De Man and Duysters (2005) define it as *cooperative agreements in which two or more separate organizations team up in order to share reciprocal inputs while maintaining their own corporate identities (De Man and Duysters, 2005).* Hamel (1991) emphasizes that in an alliance *access to people, facilities, documents, and other forms of knowledge is traded between partners in an on-going process of collaborative exchange (Hamel, 1991)*. Based on these three definitions, innovation alliances are defined in the present thesis as a cooperative agreement between two or more parties with the aim of innovating, based on ongoing collaborative exchange, in order to develop new knowledge, products and processes, while maintaining their corporate identities. The firms are mainly perceived as knowledge bases (Grant, 1996, Spender, 1996, Kogut and Zander, 1996) that try to recombine in order to create new knowledge, products and processes. A knowledge creation model of the firm has been established by Nonaka and Takeuchi (1995) and extended to the context of alliances by Feller et al. (2013). Based on this stream of literature (Foss, 2007, Foss, 2002, Feller et al., 2013), in innovation alliances, the exchange of knowledge is even more important than the exchange of material resources.

Within the open innovation literature that specifically addresses innovation in alliances (Chesbrough et al., 2008), alliances are advocated as important vehicles to get access to external knowledge and resources in order to innovate in a more cost and time–efficient way. Strategic alliances were found to outperform mergers and acquisitions in terms of enhancing the innovation performance at the company level for large companies and for SMEs (Sabidussi, 2009). With open innovation a still growing trend across industries, alliances have been in the research focus for many years now (De Man and Duysters, 2005, Gulati, 1998, Meier, 2011). Since the 1980s strategic alliances are increasingly used by organizations to innovate (De Man and Duysters, 2005). The popularity of alliances came with fluctuations (De Man and Duysters, 2005, Batterink, 2009) since firms were recognizing the need to find partners to innovate, while facing the difficulties mentioned in the introduction, Section 1.1, in the alliance collaboration process itself, due to complex management problems, dealing with appropriation concerns, motivational problems, leakage of sensitive information and partner dependency (Omta and Van Rossum, 1999, Gulati and Singh, 1998, Nooteboom, 2002).

Chiesa and Manzini (1998) suggest looking at alliance formation (they used the term ‘technology partnering’ or ‘technological cooperation’) as a process, composed of six distinct phases (Figure 1.1). First, there is the phase of goal definition by the initiating organization(s). The second phase is the cooperation partner(s) selection phase, where technological, organizational and social proximity (Cantner and Meder, 2007) and cognitive distance (Nooteboom et al., 2007) play an important role. With the selected partner(s) (formal and/or informal) collaboration agreements have to be made before the implementation and the execution of the partnership activities lead to the innovation output. Periodically, during the go/no-go change moments, corrective actions can be introduced based on the evaluation of the collaboration up to that moment. Finally, based on the innovation output the collaboration’s performance data can be assessed and used to introduce corrective actions for a possible new collaboration.

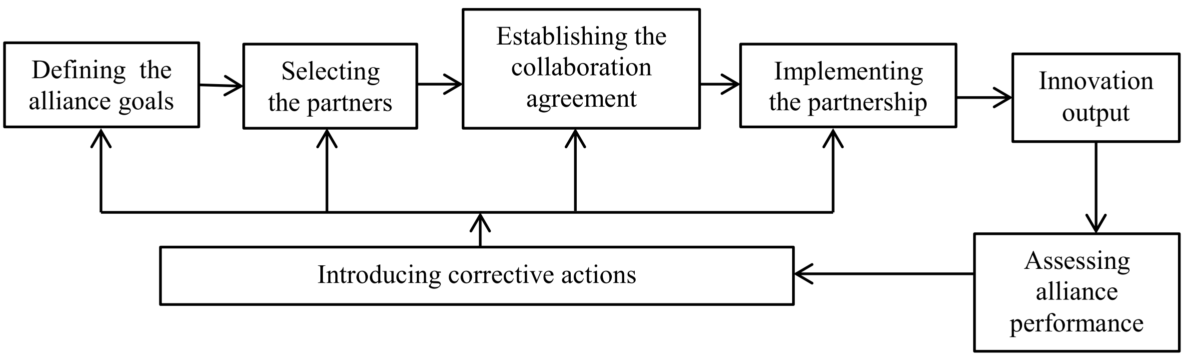

Figure 1.1 The process of technology partnering (based on Chiesa and Manzini, 1998)

Before an innovation alliance as a governance mode for external sourcing (Sabidussi, 2009) is taken into consideration, it needs a close look at the company goals that may suggest using this governance mode. Different types of alliances are motivated by different goals (Rothaermel and Deeds, 2004) and more than 85% of joint R&D agreements, equity investments, R&D joint ventures together with research cooperations are strategically motivated (Hagedoorn, 1993). Koza and Lewin (1998) argue that an alliance intent is at any time related to exploration or exploitation objectives, and Das and Teng (2000) stress that the desire to acquire resources and capabilities is one of the primary motivations for starting an alliance. However, partner(s) have to be selected with care. The goals of partners entering an alliance can be conflicting, e.g. if one partner intends to acquire the core competences of the other partner. A potential partner company could be interested in acquiring the tacit knowledge hold by scientists of the partner company and is even more likely to enter an alliance with that intention if the quality of their own scientific team decreases (Patzelt et al., 2008). In case the targeted human resources are highly mobile, this knowledge is then put at respective risk in the alliance (Harrigan, 1988). Grant (1996) states that *unlike physical and financial assets, employment contracts confer upon the firm only partial and ill-defined ownership rights over employees' knowledge assets.* A firm could try to buy those human resources away from a successful innovating company after the key persons holding the knowledge have been identified due to network or alliance engagement in order to replicate the innovation. Replication involves transferring or redeploying competences from one concrete economic setting to another (Teece et al., 1997). Thus the company that is left by a key scientist, might not only lose a human asset but possibly even have bred its own competitor (Jones and George, 1998). The need arises to find means that enable resource position barriers (Wernerfelt, 1984). Therefore, after a careful partner selection, based on the network reputation of a company, collaboration agreements have to be established to provide clarity, e.g. concerning intellectual property (IP) related issues. In conclusion, the competing dimension strongly distinguishes the innovation alliance from in-house innovation. The possibility of behaving opportunistically within the alliance (Deeds and Hill, 1999, Gulati and Singh, 1998) provides a burden that does not exist for in-house innovation projects.

As was already introduced in Section 1.2, the uncertainty inherent in innovation is an important factor underlying innovation failure. This problem may be even more severe in inter-organizational innovation. Next to the (exogenous) technological development uncertainty another (endogenous) uncertainty related to the reliability of the innovation alliance partner(s) has to be faced (Folta, 1998). Therefore, the implementation of a partnership is a process of higher complexity compared to the in-house innovation process. The access to additional resources in an inter-organizational innovation project comes at the price of additional innovation uncertainty. Therefore, the open innovation encompasses, next to a higher innovation potential, also a greater innovation process coordination challenge, which requires on top of the intra-organizational also good inter-organizational innovation process coordination, which may imply additional coordination costs. Indeed, Bruce et al. (1995) found in a survey of 106 companies from the information and communication industry, that every second respondent stated that collaborations would not speed up the innovation process, but make it more expensive. Respectively, a high(er) coordination efficiency due to adapted innovation governance is required to prevent the innovation coordination costs from exceeding the open innovation benefits

1.3 Theoretical perspectives

Schumpeter (1911[1934]) provides examples of innovations, such as *the creation of a new good which more adequately satisfies existing and previously satisfied needs* or *changes in the productive process* [….], *to create a discrepancy between their existing price and the new costs*. Schumpeter introduces innovation as a means for an entrepreneur to achieve competitive advantage, making use of the company's knowledge as a key resource to be managed, described by its own research discipline, named knowledge management (Easterby-Smith and Lyles, 2011, Spender, 2005, Easterby-Smith et al., 2008). Foss (2007) criticizes the neglecting of *governance mechanisms as antecedents of knowledge processes*, which leads to a research gap concerning the *governance of knowledge intensive firms* as well as a limited understanding concerning *the importance of knowledge for competitive advantage*.

In this book different theoretical perspectives are used to shed light on the complexity of innovation in inter-organizational settings at the network and the strategic alliance levels. Section 1.3.1- 1.3.4 will introduce the different theories that are used in the present thesis to frame the research on innovation management. The innovation systems theory is used to analyze innovation management support by cluster organizations at the network level (Chapter 2). The knowledge/resource based view and the knowledge governance perspective are used to analyze innovation management at the strategic alliance level (Chapters 3 and 4, see Figure 1.2).

1.3.1 Innovation systems theory

Innovation networks can be defined as sets of alliances between two and more organizations that are in an interactive way involved in an innovation process. Empirically they are loose or contractual links between two or more companies and other organizations and have a core with weak and strong ties among constituent members that remain independent agents (Enzing, 2009). Breschi and Malerba (2005) list a number of important theoretical perspectives to study innovation within innovation networks (referred to as 'clusters'), such as localized knowledge spill over, economic geography/regional economics, evolutionary theory, social network approach and the concept of innovation systems. All these *theoretical perspectives share the common view that interactions, formal and informal relations and more generally network effects are the key mechanisms through which external economies benefit local firms and are ultimately responsible for the emergence, growth and success of a cluster of innovative firms* (Breschi and Malerba, 2005). An innovation system (IS), in general, consists of all actors, contributing to developing, diffusing and utilizing new products and processes. Actors are entrepreneurs, suppliers, processors and retailers, but also researchers, consultants, and policy makers (Bergek et al., 2008). The innovation systems concept was first applied on the national level (Lundvall, 1988, Lundvall, 1992, Nelson, 1993), and on the sectorial level (Breschi and Malerba, 1996, Malerba, 2002, 2004). For national innovation systems a number of definitions are found (see OECD, 1997). Cooke (2004) defines the Regional Innovation System (RIS), which is the focus in Chapter 2 of this book, as *interacting knowledge generation and exploitation subsystems linked to global, national and other regional systems*.

Gaps in connectivity and collaboration between the actors of an innovation system may reduce the performance of an IS (Bergek et al., 2008), creating the need for intermediary organizations to increase innovativeness. Howells (2006) defines an intermediary organization as *an organization or body that acts as agent or broker in any aspect of the innovation process between two or more parties*. The term 'cluster organization' will be used throughout the present thesis for intermediary organizations *focused on a particular industrial sector and dedicated to brokering innovations between the actors in the sectorial system as an* *instrument of public policy* (Winch and Courtney, 2007). The ultimate goal of a cluster organization should be to facilitate inter-organizational innovation processes, which could take place in the form of an innovation alliance, which brings us back to the definition of innovation networks as 'sets of alliances', stated above in this section. Chapter 2 focuses on the position of the cluster organization to support innovation networks using an innovation systems perspective.

1.3.2 Resource/knowledge based view

A better understanding of the potential benefits of strategic technology partnering can be achieved by the application of the resource based view (RBV) (Nooteboom et al., 2007). The RBV, developed by Wernerfelt (1984), is an influential theoretical framework for understanding how competitive advantage is achieved and how that advantage can be sustained over time (e.g. Barney, 1991, Barney, 2001, Barney et al., 2011, Hart, 1995, Peteraf, 1993). There are two basic assumptions RBV is founded on: Companies in an industry do not all possess the same resources, which constitutes resource heterogeneity, while the partial immobility of these resources preserves this state of resource heterogeneity. Resources include all assets, capabilities, organizational processes, attributes, information etc. that should enable the company to act in a strategic way, trying to gain competitive advantage, (Barney, 1991). The RBV demands all resources to be rare, inimitable, non-substitutable, and imperfectly mobile, and the company needs to be able to exploit them. The dynamic capabilities approach is another explanatory approach for competitive advantage and is seen as an extension of the RBV, applied to dynamic markets (Fortuin, 2007). It will be discussed as an RBV sub item, as it is to large extents using the same terminology and rather states a special perspective of the RBV focusing on asset accumulation, replicability and inimitability (Teece et al., 1997), than representing a totally new paradigm. Also Barney (2001) agrees, that *the logic developed* (in the RBV) *applies as well to rapidly changing markets and dynamic capabilities as it does to stable markets and resources and capabilities*. Still, for having a closer look at the special requirements of fast changing markets and technologies the literature on dynamic capabilities (e.g. Teece and Pisano, 1994) provides interesting insights. Dynamic capabilities are needed as the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments (Teece et al., 1997). Alliances for example enable resource flows between organizations and further allow them to share costs as well as risks (Eisenhardt and Schoonhoven, 1996). Following the RBV, the formation of an alliance can therefore be motivated by the goal of building a unique set of resources or gaining the ability to exploit them.

Comparable to the RBV Teece et al. (1997) name technological assets, complementary assets, financial assets, reputational assets, structural assets, institutional assets, market assets, organizational boundaries as elements to explain the competitive advantage of a firm. *What firms can do and where they can go is rather constrained by its positions* (asset positions) *and path (Teece et al., 1997)*. A path not only defines what choices are open to the firm today, but also puts restrictions on what its internal repertoire is likely to be in the future (Teece et al., 1997). This path-dependency especially impacts the inter-organizational collaboration level. Asset positions matter, their assessment before joining a network or entering an alliance might play a key role. To allow companies to learn from each other further requires common codes of communication and coordinated research activities (Teece et al., 1997). But even assuming that an alliance has been formed according to the assessment of all asset positions and common codes of communication are in place, the alliance itself is dynamic. Asset positions change and require new evaluations from time to time, to collect information to estimate advantages from the exchange and to evaluate their partners' behavior. A second purpose of alliance evaluation is to prevent opportunistic behavior which is less likely in the honeymoon period than in the later stages of the alliance (Deeds and Hill, 1999).

RBV (Barney, 1991, Barney, 2001, Barney et al., 2011) further identifies knowledge as the key resource of the company, while highlighting that even complex physical technology is not inimitable, in contrast to the knowledge embedded in humans. A second factor, making a resource imperfectly imitable, is causal ambiguity. *It exists, when the link between the resources controlled by a firm and a firm's sustained competitive advantage is not understood or understood only very imperfectly* (Barney, 1991), which relates to knowledge as the key to the competitive advantage. This calls for a shift from the RBV to the knowledge based view (KBV) to assess the factors underlying innovation alliance formation and performance (Heiman and Nickerson, 2002, Spender, 1996, Grant and Baden-Fuller, 2003, Grant and Baden-Fuller, 1995). Grant (1996) states *that the resource-based view of the firm is less a theory of firm structure and behavior than an attempt to explain and predict why some firms are able to establish positions of sustainable competitive advantage*.

The KBV, an extension of the RBV (Grant, 1996), compensates for that and explains the competitive advantage of a firm by focusing on knowledge as the key resource to be managed (Grant, 1996, Winter, 1998, Kogut and Zander, 1992) and therefore takes much more the organization's behavior into account in explaining the competitive advantage of a single company or alliance. According to Nooteboom (2000) *knowledge transfer between the alliance partners in all its complexity is the core of every innovation alliance*. From the KBV the imperfect mobility of knowledge may provide a competitive advantage to the single company, but can become a severe problem in the alliance cooperation aiming at joining the unique knowledge resources, for the alliance partners should be able to make sense of the knowledge resources that are joined (e.g. Weick, 1995, Choo, 2001). This requires absorptive capacity within the alliance, which refers to the partners' capability to recognize the value of new information, their ability to assimilate it and to apply it to commercial ends (Cohen and Levinthal, 1990). Absorptive capacity is dependent on information redundancy (Nonaka, 1994). If the cognitive distance between partners gets larger, the level of absorptive capacity decreases (Nooteboom, 2000, Nooteboom et al., 2007). However, there is a value of newness in knowledge resources that forms the motivation to engage into the alliance up front. Therefore, there is a trade-off between cognitive distance and knowledge transfer in an alliance. While this first KBV aspect deals with the challenge to knowledge resource mobility within an alliance, the second challenge consists in preventing the knowledge that has become mobile from going out of control. Especially in knowledge intensive industries, the risk of transferring valuable knowledge to an opportunistic partner is substantial (Deeds and Hill, 1999). Underlying this opportunistic behavior in an inter-organizational collaboration can be conflicting goals of the participating organizations, a problem discussed by Grant (1996) for the intra-organizational context, which can be even more severe in the inter-organizational collaboration context. This states a specific burden to innovation alliances, which demands good governance to overcome it. There are consequently risks attached to innovation alliances, such as the uncertainty of research findings that can only be shared, but not reduced, while a second type of risk, deriving from the partnership interaction itself, such as opportunism, can possibly be lessened (Gilsing and Nooteboom, 2006). In the present thesis the RBV and KBV are used in Chapter 3 and 4 to explain the potential of the companies in an innovation alliance to plan and conduct the competitive effort effectively.

1.3.3 Knowledge governance perspective

'Lupus est homo homini, non homo, quom qualis sit non novit' (A man is a wolf to his fellow man, not a human, if he does not know him). This statement, first made by Titus Maccius Plautus in 195 B.C. and picked up by Thomas Hobbes in 1642 in his work 'De Cive', contains the basic assumption underlying the structural and relational perspective that is used in the present thesis to look at innovation alliances (e.g. Faems et al., 2008, Tepic, 2012). The structural perspective focuses on the first part of the sentence and looks at humans as being self-interested, calculating and rational, which may include opportunistic actions. The relational perspective builds on the second part of the sentence, suggesting that getting to know each other can help to overcome this opportunistic attitude. The structural perspective is based on transaction costs economics (Williamson, 1989) and contract theory (Hagedoorn and Hesen, 2007). The relational perspective builds on social exchange theory with the 'social' human being, who is able to trust and who can be trusted (Granovetter, 1985, Zaheer and Venkatraman, 1995, Larson, 1992, Gulati, 1995, Uzzi, 1997, Dyer and Singh, 1998). In terms of governance, the structural perspective implies building on detailed contracts and agreements (Poppo and Zenger, 2002), while relational governance tries to substitute these structural elements by social norms, reinforced by social interaction (Zenger et al., 2002, Dekker, 2004, Grandori and Furlotti, 2010) and a high level of information exchange (Caniëls and Gelderman, 2010). The substitutability between structural and relational governance mechanisms has been challenged (e.g. Poppo and Zenger, 2002, Zheng et al., 2008, Gulati, 2007, Grandori, 2001) and it is argued that there is also a complementarity between structural (contract functions) and relational governance to be stated. Structural agreements have been further criticized as too expensive (Gulati, 1995, Uzzi, 1997, Dyer and Singh, 1998) and too restrictive regarding explorative learning (McGrath, 2001). However, also positive effects from structural agreements on knowledge mobility are reported (Dhanarag and Parkhe, 2006). Nooteboom (2000) provides a literature review on the problems of governing knowledge transfer. He lists the notion of "hostages", redistribution of ownership of specific investments, a balance of mutual dependence, and reputation mechanisms as possible governance mechanisms for dealing with these problems. Foss (2007) defines the knowledge governance approach as the *sustained attempt to uncover how knowledge transactions* - *which differ in their characteristics* - *and governance mechanisms* - *which differ with respect to how they handle transactional problems -, are matched, using economic efficiency as the explanatory principle.* Foss (2007) builds his knowledge governance approach on earlier governance mechanism choice discussions (e.g.Grandori, 1997, Osterloh and Frey, 2000, Grandori, 2001), while the knowledge governance approach *asserts the need to build micro-foundations based in individual action and interaction for organizational knowledge-based phenomena*. The knowledge governance approach builds further on the distinction between tacit and explicit knowledge (Winter, 1987, Polanyi, 1962) and to what extent this knowledge to be exchanged is new (Contractor and Ra, 2002). Within an innovation alliance the knowledge governance is assumed to depend rather on the newness of the knowledge for the alliance partner, than on the overall newness of the knowledge, which makes the concept of cognitive distance (Nooteboom, 2000, Nooteboom et al., 2007) applicable for this study. In contrast to earlier knowledge management literature that largely ignored the governance cost (Foss and Mahnke, 2003), the knowledge governance approach also builds on transaction cost economics. The knowledge governance approach is used in Chapter 4 to explain the establishment of collaborative agreements and the execution of the innovation alliance related to innovation alliance performance.

1.4 Thesis setup

The remainder of this book is organized as follows. The Chapters 2, 3, 4 and 5 present four empirical studies, addressing the questions around innovation management using different theoretical perspectives and zooming in from the network, via the alliance to the level of a specific Public Private Research Partnership (PPRP) of the Center of BioSystems Genomics (CBSG, see Figure 1.2).

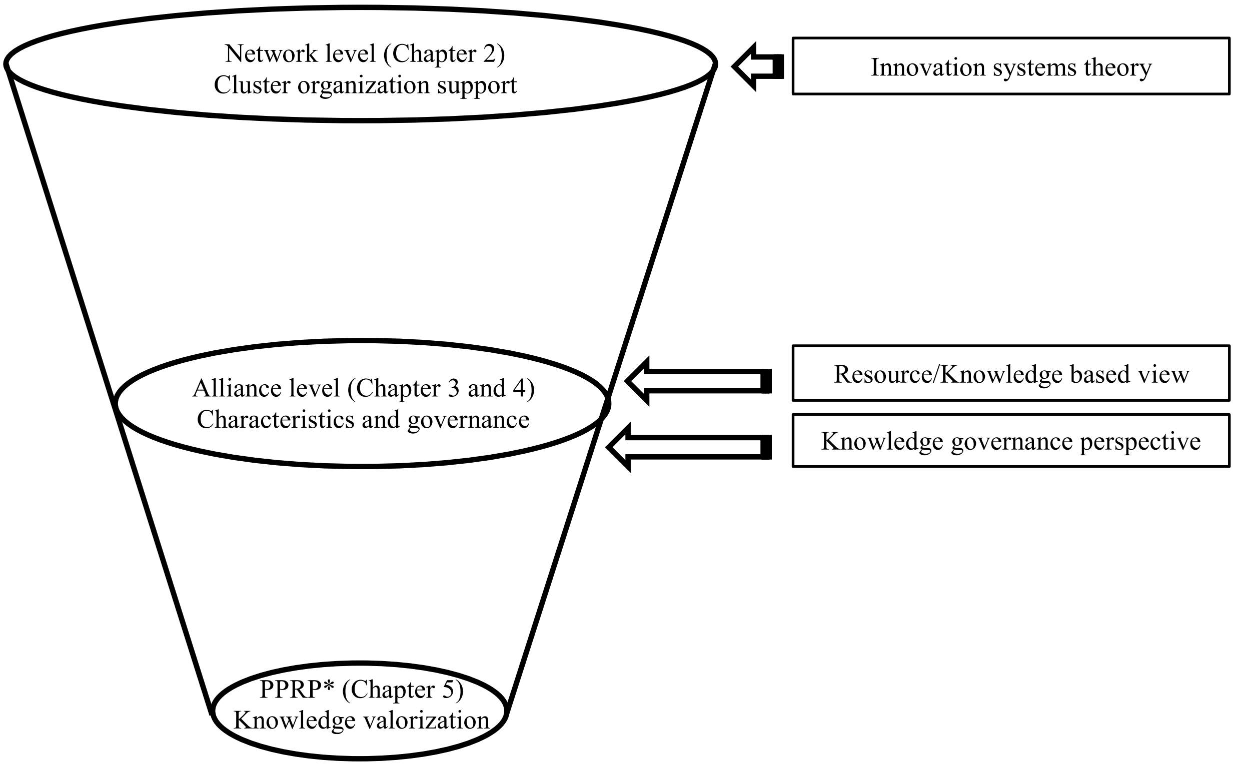

Figure 1.2. Chapter overview
* PPRP = public-private research partnership: Center for BioSystems Genomics (CBSG)

The study presented in Chapter 2 assesses innovation management at the network level, in a cross sectional case study of three Dutch innovation clusters. This study explores how cluster organizations assist their member organizations in overcoming their innovation and cooperation obstacles. The innovation networks (innovation clusters) are assessed employing the innovation system theory concerning the functioning of the network as a whole, while specifically addressing the functions executed by the network (coordinating) support organization (from now on named 'cluster organization').

In the literature a number of functions of cluster organizations, such as innovation process management, demand articulation, network formation support, (Batterink, 2009, Klerkx and Leeuwis, 2008, Klerkx and Leeuwis, 2009, van Lente et al., 2003) and internationalization support (Omta and Fortuin, 2013) are described. In this context Asheim and Coenen (2005) criticize the *high-tech fascination* (Asheim and Coenen, 2005, Asheim et al., 2011) when it comes to cluster research, causing the differentiation of innovation mechanisms on other technological levels to be neglected. Batterink et al. (2010) add that more research is needed to uncover *the way in which innovation brokers* (cluster organizations) *function in different types of innovation networks* (Batterink et al., 2010), while Winch and Courtney (2007) conclude in their review of intermediary organizations, that *research has, to date, only just started to identify how innovation brokers and innovation intermediaries more generally operate, and in which conditions different types of brokers function most effectively* (see also Boon et al., 2011, Boon et al., 2008, Sapsed et al., 2007). It is therefore the objective of the study presented in Chapter 2, to investigate how cluster organization functions are implemented in the different clusters and to compare the governance mechanisms employed. The research question guiding the exploratory study is consequently:

Research question 1: Are there differences to be observed in cluster organization support in different clusters (electronics, green biotech and agrifood) (1a) and, if so, what can be learned from these differences (1b)?

To answer research question 1, three clusters were selected that were created at about the same moment, but are active in different sectors, an agrifood cluster, a green biotech cluster and an electronics cluster, all situated in the Netherlands. Per cluster three to four open interviews were conducted with the director of the cluster organization, a representative of the knowledge institution working closely together with the companies in the cluster and one or two regional political representatives. In addition, semi-structured interviews were held with the CEOs of three to four SMEs, and the R&D managers (mostly CTOs) of four large member companies per cluster (Table 2.1).

Chapter 3 and 4 focus on the alliance level. Chapter 3 aims at contributing to our understanding of the dynamics of innovation alliances by exploring the impact of different alliance characteristics on the alliance innovation performance of Dutch biotechnology SMEs. Bagchi-Sen et al. (2011) mention the following barriers to innovation that specifically apply to SMEs: *lack of skilled managers or researchers, a lack of physical facilities for research or manufacture, as well as a lack of marketing or distribution channels.* SMEs may suffer from resource constraints (Narula, 2004, O'Regan et al., 2006), but at the same time they generally have a lower bureaucratic burden. They are usually considered to be more flexible and therefore better innovators. Unique competencies, a low level of hierarchy and a high internal flexibility (Nooteboom, 1994, Pisano, 2006) make up for their lower financial power (Argyres and Liebeskind, 2002). A general overview of the advantages and disadvantages of SMEs, not limited to the biotech sector, is provided in the literature review of Ebrahim et al. (2010), while Khilji et al. (2006) conducted exploratory research specifically on the challenges of biotech SMEs. Rothaermel and Deeds (2004) found in a study on 325 health related biotechnology companies that the forming of alliances was an effective tool to overcome the problems of limited resources, such as capital constraints (Khilji et al., 2006) and to accelerate innovation (Terziovski and Morgan, 2006). Alliances allow access to missing competences and material resources and thus enhance the innovative potential and ultimately firm performance (Hall and Bagchi-Sen, 2002, 2007). However, Khilji et al. (2006) indicate that not enough is known on how to successfully manage a strategic alliance. Pisano (2006) criticizes that business models, organizational strategies and approaches from other high-tech sectors have been used while not taking into account the special characteristics of the biotech sector, and that *organizational and institutional innovations are needed to unlock the potential of biotechnology*.

The high level of innovativeness of the biotech sector, combined with the high level of alliance formation makes it an ideal sector to study the critical success factors for collaborative ‘open’ (Chesbrough, 2006) innovation. To date, a number of empirical studies have been carried out to study alliance collaboration in this sector. They focus on company performance related to the alliance portfolio (see Baum and Silverman, 2004, George et al., 2001), the network composition and dynamics (Gay and Dousset, 2005), and the alliance duration in an uncertain environment (Pangarkar, 2003). The alliance collaboration process concerning knowledge management (e.g. Nooteboom et al., 2007, Standing et al., 2008), alliance capabilities (Heimeriks and Duysters, 2007) and governance (Phene and Tallman, 2012) are also the focus of more recent studies. However, a literature review (not only on biotech alliances) done by Comi and Eppler (2009) still highlighted a lack of research on alliance management.

The objective of Chapter 3 is to fill up this gap by studying the alliance collaboration process of successful and less successful innovation alliances among biotech SMEs. The research question guiding the study in Chapter 3 is consequently:

Research question 2: Which characteristics are positively and/or negatively related to the performance of innovation alliances of biotech SMEs?

Chapter 3 attempts to show the interaction effects among the alliance performance factors in a structural equation model. For the empirical testing quantitative questionnaire data of 40 Dutch innovation alliances, provided by 18 biotech SME alliance coordinators were used. By limiting the modeling attempt to the well-researched, highly specific type of biotech SMEs innovation alliances, the foundations for an alliance collaboration model could be laid.

Chapter 4 uses the findings of the alliance collaboration model developed in Chapter 3, and tests them in a European, cross sectional, quantitative study of 94 alliances to highlight the role of structural and relational governance in the alliance collaboration process. Critical issues that play a role in an alliance range from which company is contributing what, is the exchange of knowledge symmetric enough (problem of outlearning the partner, Hamel, 1991) to which company is benefiting most from the results. Based on the number of partners involved in an alliance and the interdependencies between the partners, a balance of contributions and results should be aimed for. To achieve this balance, different governance mechanisms are employed. In Chapter 4 a differentiation between structural and relational governance mechanisms is made (Faems et al., 2008). In innovation literature much attention has been spent on relational governance, which is expected to offer the flexibility needed for innovation (e.g. Child and McGrath, 2001), while relational governance is expected to substitute for structural governance (Dyer and Singh, 1998, Gulati, 1995, Larson, 1992, Adler, 2001). However, Poppo and Zenger (2002) challenge this assumption and show in their study based on a cross-sectorial sample of 285 relationships that structural and relational governance complement rather than substitute each other. Also Tepic et al. (2011) showed in a case study of 18 sustainability oriented innovation partnerships in the Dutch agrifood-sector the advantages of a good interplay of structural and relational governance to mitigate the organizational challenges of innovation uncertainty and network heterogeneity.

Chapter 4 aims to extend the work on the use of different governance mechanisms in a cross-sectorial study of 94 innovation alliances to answer the following research question.

Research question 3: What is the impact of the use of different structural and relational governance mechanisms on the performance of innovation alliances?

Chapter 5 takes a closer look at the impact of the complexity of the innovation process in an inter-organizational setting by zooming in from the level of the innovation networks and the innovation alliances to the specific case of a number of innovation alliances that combined form one innovation network, namely a public private research partnership (PPRP). PPRPs aim at combining *"the resources of government with those of private agents (business or not-for-profit bodies) in order to deliver societal goals"* (Skelcher, 2005). Since the resources of government include publicly financed research organizations, knowledge is one of the main resources that is brought into the research partnerships from the public side (Perkmann and Walsh, 2008), to transform it into value for society. Perkmann and Walsh (2007) introduce the term public private research partnership (PPRP) that will be used throughout this thesis. Recent studies show a widespread use of university-industry partnerships in Austria (Schartinger et al., 2002), the United Kingdom (D'Este and Patel, 2007) and Germany

(Meyer-Krahmer and Schmoch, 1998). However, there are also some concerns about the effectiveness of PPRPs. Geisler (2001) argues that gains of PPRPs appear mainly in leveraged R&D rather than in the number of product innovations, while Feller (2005) claims that firms, by establishing relationships with universities, aim at generic benefits, such as getting in contact with young researchers as possible future employees, rather than to commercialize innovations. It is further questionable whether the effectiveness of knowledge utilisation by companies in PPRPs can be expected to be independent of contingencies or instead dependent upon certain parameters, such as company size (Fontana and Geuna, 2005, Santoro and Chakrabarti, 2002) or type of industry sector (Widdus, 2001). Adams (1990) found a time lag of approximately 20 years between the starting of research and the moment that industries can profit. Therefore another interesting parameter to be taken into account is the complexity of the innovation, which is reflected by the length of the product generation life cycle (PGLC). The PGLC is the sum of the product life cycle of all related products belonging to one product generation. Fortuin (2007) identified the innovation complexity underlying the PGLC length in a cross-industry study as the dominant factor affecting the entire innovation process, from the knowledge generation up to the market introduction of the final product. This raises the question whether innovation complexity also has an impact on the effectiveness of PPRPs.

Differences in innovation complexity are especially also found in plant breeding. E.g., there are differences in breeding complexity between potato and tomato breeding. Diploid tomato cultivars require 3 to 8 years to be bred, while, due to the tetraploid genome, potatoes require 10 to 20 years to be bred and propagated for release. For potatoes, molecular breeding possibilities are currently limited compared to tomato molecular breeding. Consequently, tomato and potato companies show a tremendous difference in breeding innovation complexity, which makes them an ideal study population to answer the research question:

Research question 4: Does the technical complexity of the innovation process, as reflected by the length of the product generation life cycle (PGLC), influence the knowledge valorization process in a public private research partnership (PPRP) in the plant breeding sector (4a), and if so, in what way (4b)?

Research question 4 is addressed in Chapter 5 by researching the PPRP, Center of BioSystems Genomics, in which seven of the 15 participating companies belong to the tomato industry and eight belong to the potato industry.

Chapter 6 draws conclusions and indicates the main contributions to literature. This chapter ends with a discussion of the managerial implications for alliance managers and cluster coordinators and with recommendations for policy makers.

Chapter 2

Management of innovation networks through cluster organizations[1]

2.1 Introduction

Since the success stories of Silicon Valley the organization of companies in clusters received the attention of governments around the world as a method to stimulate innovation. In the literature a number of high-tech clusters are compared with Silicon Valley, such as the Silicon Wadi in Israel (De Fontenay and Carmel, 2004), the software cluster in the Dublin region in Ireland, the software cluster in the Bangalore region in India (Arora et al., 2004), the Scandinavian clusters of mobile phones in Sweden and Finland (Richards, 2004) and the Hsinchu region cluster in Taiwan focusing on IT hardware (Saxenian, 2004). All these clusters showed annual double digit growth rates concerning the number of new firms, revenues, employment and exports (Bresnahan and Gambardella, 2004). The research of Bresnahan and Gambardella (2004) also focused on how to start a cluster and what role the government could have in terms of creating a framework to successfully create a new cluster.

Bresnahan and Gambardella (2004) point to the special role of the cluster coordinating organization (from now on cluster organization as intermediary organizations within the cluster) in creating successful clusters. Johnson (2008) indicates a need for research to clarify the role of contextual factors, such as the technology level, in the effectiveness of the cluster organization. While much is known about the clusters and cluster organizations in the high-tech sector, much less is known about their functioning in other sectors. Since clear sector differences have been identified in innovation (Malerba, 2004) linked to the technology level of different sectors (e.g. based on the R&D input level, Pavitt (1984)) it was decided to compare clusters in the high-tech, the medium-to-high-tech (the green biotech) and the low-to-medium-tech (the agrifood) sector.

In the literature a number of functions of cluster organizations, such as innovation process management, demand articulation, network formation support, (Batterink, 2009, Klerkx and Leeuwis, 2008, Klerkx and Leeuwis, 2009, van Lente et al., 2003) and internationalization support (Omta and Fortuin, 2013) are described. In this context Asheim and Coenen (2005) criticize the *high-tech fascination* (Asheim and Coenen, 2005, Asheim et al., 2011) when it comes to cluster

[1] This chapter is based on the publication: Garbade, P.J.P., F.T.J.M. Fortuin and S.W.F. Omta, (2013). Coordinating clusters: A cross sectoral study of cluster organization functions in The Netherlands. *International Journal on Food System Dynamics*, 3(3), 243-257.

research, neglecting the differentiation of innovation mechanisms on other technological levels. Batterink et al. (2010) add that more research is needed to uncover *the way in which innovation brokers function in different types of innovation networks* (Batterink et al., 2010), while Winch and Courtney (2007) conclude in their review on intermediary organizations, that *research has, to date, only just started to identify how innovation brokers and innovation intermediaries more generally operate, and in which conditions different types of brokers function most effectively*. It is therefore the objective of this chapter to investigate how cluster organization functions are implemented in the different clusters.

For the present study, three clusters were selected that are about the same age, but active in different industries at different technological levels, all situated in the Netherlands. An agrifood cluster represents the low-to-medium-tech level, a green biotech cluster the medium-to-high-tech level and as a third cluster a non-food high-tech cluster based on nano-electronics, embedded systems and mechatronics was chosen. Per cluster three to four open interviews were conducted with the director of the cluster organization (and in the green biotech cluster also the Chairman of the Advisory Board, the CTO of one of the big member companies), a representative of the knowledge institution working closely together with the companies in the cluster and one or two regional political representatives. In addition, semi-structured interviews were held with the CEOs of three to four SMEs, and the R&D managers (mostly CTOs) of four large member companies.

Chapter 2 is structured as follows. Section 2.2 describes the theoretical foundation of the study. Section 2.3 describes the development of the interview guide, the methods of data collection and the analyses used. Section 2.4 starts with the baseline description of the three clusters and presents similarities and differences regarding the intermediary functions. Finally, in Section 2.5 the results are discussed and the conclusions are drawn.

2.2 Theoretical framework

A cluster is defined as a *geographic concentration of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (for example, universities, standards agencies, and trade associations) in particular fields that compete but also co-operate* (Porter, 2008, Porter, 1998). Breschi and Malerba (2005) list a number of important theoretical perspectives on research innovation within clusters, such as localized knowledge spill over, economic geography/ regional economics, evolutionary theory, social network approach and the concept of innovation systems. All these *theoretical perspectives share the common view that interactions, formal and informal relations and more generally network effects are the key mechanisms through which external economies benefit local firms and are ultimately responsible for the emergence, growth and success of a cluster of innovative firms* (Breschi and Malerba, 2005).

For the present chapter the concept of innovation systems is chosen to shed light on the cluster organization functions in clusters around different technology levels. The innovation systems concept was first applied on the national level. For national innovation systems a number of definitions are found (see OECD, 1997). Cooke (2004) defines in contrast the Regional Innovation System (RIS) as *interacting knowledge generation and exploitation subsystems linked to global, national and other regional systems*. Clusters and RIS are used as exchangeable terms throughout the present chapter. This means that the author does not share the distinction made by Asheim and Coenen (2005) and Asheim et al. (2011) since the distinction is based on a redefinition of the cluster term that has been defined differently before by Porter making the distinction between the RIS and Cluster term invalid.

An Innovation system (IS), in general, consists of all actors, contributing to developing, diffusing and utilizing new products and processes. Actors are entrepreneurs, suppliers, processors and retailers, but also researchers, consultants, and policy makers. Gaps in connectivity and collaboration between those actors may reduce the performance of an IS (Bergek et al., 2008), creating the need for intermediary organizations to increase innovativeness. Howells (2006) defines an intermediary organization as *an organization or body that acts as agent or broker in any aspect of the innovation process between two or more parties*. Winch and Courtney (2007) use the term ‘innovation broker’ for intermediary organizations *focused on a particular industrial sector and dedicated to brokering innovations between the actors in the sectorial system as an instrument of public policy.* In this chapter the innovation broker role is fulfilled by the 'cluster organization'. They act as member of a network, enabling the other members to innovate and are semi-public organizations. Klerkx and Leeuwis (2009) identified three functions of the cluster organization. Omta and Fortuin (2013) added the internationalization support function specifically aiming at SMEs. The definitions of the different functions are provided below.

Innovation process support
Enhancing alignment and learning of the multi-actor network, which involves facilitating learning and cooperation in the innovation process (Klerkx and Leeuwis, 2009).

Demand articulation support
Articulating innovation needs and corresponding demands in terms of technology, knowledge funding and policy (Klerkx and Leeuwis, 2009).

Network formation support
Facilitating linkages between relevant actors by *scanning, scoping, filtering, and matchmaking of possible cooperation partners* (Klerkx and Leeuwis, 2009).

Internationalization support
Providing *exposure at international [...] exhibitions*, supporting *international business missions* and integrating *‘ambassadors’ (researchers and business managers from other countries) advertising [...]* the cluster *member companies in their home country* (Omta and Fortuin, 2013).

2.2.1 Differences across sectors

Innovation systems may consist of companies active in all kinds of industries, but very often they focus on a specific industrial sector, the so-called sectorial innovation systems, which overlap often with an RIS (Asheim et al., 2011). Here the differentiation between high-, medium- and low-tech industries (OECD, 1986) is assumed to play a role in the functioning mechanisms of the RIS and its ‘cluster organization’. However, with very different tech-levels of companies often found within one industry or even sector this categorization is weakened (see Asheim and Coenen, 2005). Therefore it will be tried to also use alternative catergorization schemes besides the tech-level of the RIS to explain the differences found between the researched RIS in the present chapter.

Asheim and Coenen (2005) argue *that there are different logics behind constructing regional innovation systems contingent on the knowledge base of the industry it addresses as well as on the regional knowledge infrastructure that is available*. They discuss the varieties of RIS by dividing them into the territorially embedded regional, regionally networked and regionalised innovation system. These three RIS types are distinguished by the level of member interaction. In the first member companies source mainly from localised, interfirm learning processes, while in the second a regional supporting institutional infrastructure is found in place. For the third type the interaction of the members is to a larger extent focused outside the region on national or even international level. Asheim and Coenen (2005) further distinguish between ex ante and ex post approach in constructing an RIS. In cases of ex ante support, the RIS emerges from the knowledge developed by the knowledge institution/s within the RIS, while in the ex post support case often a rather mature industry relies on the problem solving provided by the knowledge institutions. Applied to the three different types of RIS mentioned above this means that ex-post support is found in territorially embedded RIS, while in the regionalised innovation system rather ex-ante support is found, while for the regionally networked innovation system both elements are typical. (see Asheim and Coenen, 2005).

2.3 Methods

In 2011, three clusters were selected that are about the same age, but active in different sectors, an agrifood cluster, a green biotech cluster and an electronics cluster, all situated in the Netherlands. Per cluster three to four open interviews were conducted with the director of the cluster organization (and in the green biotech cluster also the Chairman of the Advisory Board, the CTO one of the big member companies), a representative of the knowledge institution working closely together with the companies in the cluster and one or two regional political representatives. In addition, semi-structured interviews were held with the CEOs of three to four SMEs, and the R&D managers (mostly CTOs) of four large member companies (Table 2.1).

Table 2.1. Respondents per cluster

Interviews conducted with:	**Number of interviews per cluster**		
	Agrifood	Green biotech	Electronics
Cluster organization director	1	2	1
Regional political representative (s)	1	1	2
Knowledge institution	1	1	1
Member companies	8 (4 SMEs)*	7 (3 SMEs)*	7 (3 SMEs)*

*SMEs: Companies < 250 full time equivalents (ftes)

To make the interviews as consistent as possible, a detailed interview guide was developed, as well as a research protocol. The interview guide has been discussed extensively with an expert in the field and tested in a pilot interview. The open questions were targeted at assessing the cluster configuration, the activities of the cluster organization and the clusters governance mode. The Likert 7-point type closed questions mainly covered the company's assessment of the importance of the cluster organization's support related to the company's innovation activities, the importance of innovation for the companies and the kind of innovation partners the companies use in their 'open innovation' projects. Also the company's innovation and business performance was assessed relative to their most important competitors (For the complete operationalization see Table 2.2).

Table 2.2. Questionnaire operationalization

Concepts		**Closed questions**
Company level	**Innovation importance**	**How important is innovation to remain competitive for your company?** [1: not important at all, 7: very important]
		Please indicate the contribution of products introduced over the last three years to the total company turnover [in percent]
	Innovation performance	**Which innovations did your company achieve over the last 3 years?** [1: none; 7: many]
		New or improved products or services
		New or improved processes
		New market segment; different type of customers
		New market area (geographical)
		New business models
		New cooperative partnerships

	Business performance	**Compared to our most important competitor…**	
		our profitability is [1: much lower; 7: much higher]	
		our growth rate is [1: much smaller; 7: much higher]	
		we are much quicker in introducing new products/ services to the market [1: strongly disagree; 7: fully agree]	
	Open innovation partners	**How important are the following cooperation partners for the innovations you are working on?** [1:not important at all; 7:very important]	
		Buyers	
		Suppliers of raw material	
		Suppliers of (process) technology	
		Competitors	
		Universities and Universities of Applied Sciences	
		Research Institutes	
		Consultants	
Cluster organization level	**Cluster organization support**	**Did the cluster organization play a role in establishing the cooperation with the following partners?** [yes/no]	**Cluster function**
		Buyers	Network formation support
		Suppliers of raw material	
		Suppliers of (process) technologies	
		Competitors	
		Universities and Universities of Applied	
		Research Institutes	
		Can you indicate where the cluster contributed over the last 3 years? [1: contributed nothing; 7: contributed greatly]	
		Setting-up or expanding your network	Network formation support
		Access to highly-trained personnel	
		Housing or expanding production facilities	Demand articulation support
		Support in receiving innovation subsidies	
		Acquiring new knowledge or technology	Innovation process support
		Finding new ideas for innovation. e.g. through innovation seminars	
		How important was the role of the cluster in the achieving following innovations? [1: not important at all; 7: very important]	
		New or improved products or services	Innovation process support
		New or improved processes	
		New business models	
		New cooperative partnerships	Network formation support
		The cluster organization contributes… [1: strongly disagree; 7: fully agree]	
		to the promotion of our sector	Innovation process support
		to the innovation capacity of our company	
		by eliminating obstacles to innovation	
		by creating chances for innovation	

The data collection started with contacting the respondents, and sending them the interview guide in advance, so that they could prepare for the interview. The interviews were thoroughly prepared, by using information from the website of the organization, annual reports and by looking up public data, e.g. in a patent database. These data were used to spend the time available for the interview as efficiently as possible; and to be able to triangulate the findings of the interviews.

For the analysis of the data a mixed methodology approach was chosen, employing the qualitative and quantitative data in a complementary way to assess the nature of the researched clusters. The relation between the quantitative and qualitative data is twofold. The first is that the relations expected from the interviews (qualitative) will guide the searching for relations in the quantitative analysis. And the second is the other way around: relations found in the quantitative analysis only have value if they can somehow be explained by the qualitative data gathered. Kruskal Wallis exact tests were used to identify significant differences in the means of the three clusters.

2.4 Results

The results show a number of clear differences among the investigated clusters. General differences were found in the mode of financing and the level of interaction between the cluster organization and its member companies.

2.4.1 Baseline description

The agrifood cluster, founded in 2004, has currently more than 100 member companies of which around 60% are agrifood SMEs. The agrifood sector is taken quite broadly, from crop protection at the start to the production of consumer products at the end of the agrifood chain. The companies are mainly located within a circle of 100 kilometers, while a large part of these lie relatively close to the core of this circle, the knowledge institution. Since the knowledge institution provided large parts of the knowledge on which the cluster is based today the cluster can be classified as an ex ante regional innovation system also containing a significant number of hands on solution ex post elements. The goal of the cluster, as formulated by the coordinator, is to *increase the innovative power of the agrifood companies on the highest aggregation level by the best possible use of existing knowledge*. The cluster organization of the agrifood cluster (9 full time employees) is governed by four CEOs of the member companies and the president of the board of the main knowledge institution and one policy maker; 80% of the funding is public and 20% private. The cluster organization is also involved in a number of EU projects. Each year five “cluster members only” meetings, five open innovation seminars (not exclusively for cluster members) and an annual conference are held. The cluster organization offers a range of services, such as an innovation link, international matchmaking, and support for start-up companies, e.g. to apply for subsidies, and support to find appropriate innovation partners.

The green biotech cluster, founded in 2008, is a cluster of companies active in the green biotech industry, such as plant breeders, seed producers and companies providing breeding support by testing products or providing machinery. It is a cluster composed of competitors as well as complementary companies; 10 of the 21 member companies are SMEs (The SME definition in this thesis follows the European definition, which means companies with less than 250 full time employees). The main drivers in founding the green biotech cluster were four big seed companies. Since it was not the knowledge institute that sparked the development of the RIS, but based on the fact that the majority of the companies emerged out of a long technological tradition in this region, here an example of an ex post regional innovation system is found. The member companies are geographically clustered, as all companies are located within a circle of 30 kilometers. The cluster activities are financed for 80% by company contributions, whereas 20% comes from the central municipality. The cluster organization makes use of company resources in the form of working groups in order to execute its tasks and can therefore be regarded as a virtual organization supervised by the board of the CEOs and the cluster coordinator, the only employee of the cluster organization. There are two gatherings per year where the board and the workgroups meet. The board meets 5 to 6 times per year and the working groups meet 4 to 6 times per year. Furthermore, there is a lot of informal contact among the member companies, since the distances are small: on open days, receptions, and other networking moments. This informal contact has to be distinguished however in most cases from straight innovation cooperation contact, since this regionalized innovation system relies more on cluster independent collaboration contact on the national and international level. According to the cluster coordinator the main targets of the green biotech cluster are PR and image improvement of the sector, education and labor market support as well as knowledge and innovation support. All targets relate to the major problem of the green biotech industry. The sector is growing at a rate of about 6 % per year and the demand for highly qualified staff cannot be fully satisfied. The CEOs of the interviewed member companies described the green biotech cluster mission as respectively *finding new personnel and land development plan related issues*.

The electronics cluster, an active cluster within a larger high-tech ecosystem, founded in 2006, is a cluster of 120 high-tech companies in nano-electronics, embedded systems and mechatronics, including eight big multinationals with an annual turnover exceeding € 0.5 Billion, as well as 92 SMEs. The companies in the cluster, which has the legal status of an association since 2009, are high-tech companies, producing all kinds of products, machinery as well as consumer products. The companies are mainly located within a circle of 120 kilometers. The cluster further includes one major technical university and 11 research institutes. The construction approach of this cluster as an RIS includes ex ante and ex post elements regarding the knowledge institution contributions. The financing of the cluster is divided equally over private and public funding. The cluster organization is run by four persons. There is a program council and an executive board. In each of them are 10 representatives of the cluster members, mainly CEOs of the big companies. Most influence comes via the program council and the executive board. The member assembly, where all CEOs are present, takes place twice a year. All activities are executed by the staff from the member companies. In total 100 to 150 employees of the member organizations contribute on an irregular basis about 5% of their working time, which adds up to another 7-8 ftes. Every year a road map is created by this partly virtual organization. Twice a year there are SME matchmakings and SME workshops are held 2 to 3 times per year.

2.4.2 Company performance per cluster

The self-evaluation of the companies in the three clusters was rather good, both in terms of profitability and innovation level (Table 2.3). The respondent groups per cluster show no significant differences in terms of relative company performance. They all indicated that they slightly outperform their most important competitors in terms of profitability, growth and speed of introducing new products to the market. As could be expected, being all members of innovation clusters, all companies indicated that they give high importance to innovation as a means of staying competitive (mean of 6.7 (standard deviation, stdv 0.6) on a 7-point Likert scale). This finding weakens however the distinction of the clusters based on the technological level of the industry (see OECD, 1986) and any conclusions on the innovativeness of the clusters. Indeed the companies in the agrifood cluster indicated that 45% of their turnover was based on products that were introduced to the market in the last 3 years, with a stdv of almost 40 %. It can be assumed that this high standard deviation might derive from the diversity of companies in terms of tech level in this cluster. In the green biotech cluster and the electronics cluster the percentage of the turnover amounted to 26% (stdv 14%) and 49% (stdv 17%), respectively.

Table 2.3. Innovation performance of the companies in the three clusters

Indicator Question		Mean (Stdv)		
		Agri food	Green biotech	Electronics
Which innovations did your company achieve over the last 3 years?	New or improved products or services	6.5 (1.1)	6.3 (0.8)	6.8 (1.2)
	New or improved processes	5.5 (1.7)	5.4 (1.5)	4.2 (1.9)
	New market segment; different type of customers	5.9 (1.0)	4.0 (1.7)	2.3 (1.3)
	New market area (geographical)	5.7 (1.8)	3.0 (1.6)	4.0 (2.1)
	New business models	4.8 (1.3)	3.2 (1.3)	3.6 (2.6)
	New cooperative partnerships	6.1 (1.4)	4.8 (1.5)	5.5 (1.4)

Significant differences at $p<.05$ (two-tailed) among the three clusters are shaded grey

A significant difference was found in terms of finding new market segments and different types of customers, where the agrifood cluster companies clearly outperformed the companies from the other clusters. The same applies to finding new market areas and introducing new business models (although these differences are not statistically significant, see Table 2.3). It can be assumed that these differences can be related to a catching up situation in the agrifood sector, compared to the green biotech and the electronics sector. However, it also supports attempts to divide the researched clusters by the interaction level of its members into different types of RIS following Asheim and Coenen (2005). In this case the green biotech cluster has the status of a regionalized innovation system, the same applies to the electronics cluster, while the agrifood cluster shows more the characteristics of a regionally networked innovation system. Also from this classification of the clusters this catching up situation in terms of internationalization concerning the agrifood cluster can be explained. The agrifood companies further indicated that the cluster organization played a pivotal role in finding new clients and markets, which means crossing the typical boundaries of the RIS.

2.4.3 Cluster organization support per cluster

Table 2.4. Innovation process support

Indicator Question		Mean (Stdv)		
		Agri food	Green biotech	Electronics
Can you indicate where the cluster contributed over the last 3 years?	Acquiring new knowledge or technology	3.1 (1.6)	2.0 (1.7)	4.7 (2.1)
	Finding new ideas for innovation. e.g. through innovation seminars	2.5 (1.5)	1.6 (1.3)	3.0 (1.4)
How important was the role of the cluster in achieving the following innovation?	New or improved products or services	2.0 (1.5)	2.0 (1.7)	4.1 (1.8)
	New or improved processes	1.4 (0.9)	1.2 (0.4)	2.4 (1.7)
	New business models	1.4 (0.9)	1.0 (0)	2.8 (2.7)
The cluster organization contributes…	to the promotion of our sector	6.5 (0.5)	5.2 (1.2)	6.0 (0.9)
	to the innovation capacity of our company	4.0 (2.1)	2.6 (1.6)	4.2 (2.1)
	by eliminating obstacles to innovation	4.4 (2.2)	2.3 (1.3)	4.2 (2.2)
	by creating chances for innovation	6.0 (0.8)	2.9 (1.9)	5.8 (0.8)

Significant differences at $p<.05$ (two-tailed) among the three clusters are shaded grey

Innovation process support

Concerning the innovation process support function of the cluster organization, the promotion of the industry was evaluated as being of high importance by the companies in all three clusters (Table 2.4).

The contribution of the cluster organization in creating an environment that provides chances for innovation was evaluated as high by the agrifood cluster respondents with a mean of 6.0 and the electronics cluster respondents with a mean of 5.8. As stated by the R&D manager of a big electronics company: *that is simply the electronics cluster organization's task.* The green biotech cluster's relative low score of 2.9 was reflected by the CEO and the R&D director of two big companies who stated that the green biotech cluster is not targeting innovation directly and that innovation would happen anyway within the companies and in alliances between companies. However, it is surprising, because it does not reflect the high level of satisfaction indicated by the respondents with the achievements of the green biotech cluster organization in improving the labor market situation for the companies. They all gave credits to the achievements of the green biotech cluster organization concerning the goals it was set up for: *labor market, image, infrastructure and education,* as stated by the CEO of a large company. A similar statement came from the director of a university group, who stated: *you don't hear what other companies are into or are going to invest in. It is about the image of the sector, to attract personnel.* Apparently, the company respondents did not realize that this type of support certainly creates an environment with higher chances for innovation.

As could be expected, the importance of the three cluster organizations for the process of achieving innovations was evaluated as rather low by the company respondents. E.g. the R&D director of a big feed company stated that the agrifood cluster organization did not play a direct role in innovation, but indirectly as a means to extend the company's network, not to miss out on interesting SMEs. A manager of a research institute also stated: *Innovation we can better do ourselves, but the lobbying and providing market insights are the cluster organizations' strengths.* However, within the agrifood cluster a number of SMEs indicated that the cluster itself could play a role in the innovation process. The CTO of a very innovative food SME praised the *agrifood cluster concept as real strong and due to it a lot can happen*, while another CEO of a food technology provider indicates the agrifood cluster had speeded up his innovation process.

<u>Demand articulation support</u>

A significant difference among the three clusters was found in terms of subsidy application support (Table 2.5). The electronics cluster respondents indicated that their cluster contributed greatly with a score of 6.3 in receiving subsidies, while the agrifood cluster respondents gave it a 3.6 and the green biotech cluster respondents only a 1.4 on a 7-point Likert scale. To put this finding into context it should be mentioned that it was stated in the interviews with both SMEs and large companies that the electronics cluster organization had played a pivotal role in overcoming the problems of the economic crises that had strongly affected the electronics sector, even more than the green biotech and the agrifood sector. While the purchase of new electronic devices is immediately postponed if buyers and end consumers experience a shortage in financial resources, in the green biotech industry the cut is first made on more expensive products, while the food processors experience the crisis effects to a much lower extent.

Table 2.5. Demand articulation support

Indicator Question		**Mean (Stdv)**		
		Agri food	Green biotech	Electronics
Can you indicate where the cluster contributed over the last 3 years?	Housing or expanding production facilities	2.0 (1.9)	3.4 (2.6)	1.5 (0.5)
	Support in receiving innovation subsidies	3.6 (2.4)	1.4 (0.9)	6.3 (0.8)

Significant differences at p<.05 (two-tailed) among the three clusters are shaded grey

The electronics cluster organization helped in setting up open innovation collaboration projects between electronics SMEs and large companies and supported in finding subsidies for these projects. As phrased by a CEO of a high technology providing SME: *The electronics cluster organization did more than only matchmaking* and the technology manager of a broadcast technology producer adds: *The electronics cluster organization also developed the road map that determined where subsidies were paid for*. It was emphasized by the R&D director of a big multinational that this *allowed companies to keep their R&D staff and made companies coming closer together*. Especially in the electronics cluster, promotion of the industry towards the government played a pivotal role also in receiving subsidies to overcome the crisis. Here the importance of speaking with a common voice, reflected in *the industry roadmap,* was highlighted by the respondents of the SMEs and the big companies. Also a high identification level could be observed, e.g. *we are the electronics cluster* was stated by an R&D manager of a big electronics company.

In the case of the agrifood cluster, the R&D director of a big feed company and the CEO of a food technology providing SME mentioned the importance of the cluster organization for finding subsidies for open innovation cooperation. The coordinator of the green biotech cluster explicitly stated not to support companies in the process of application for innovation subsidies, but to limit the support by pointing at upcoming subsidy possibilities.

On the qualitative level a number of findings should be added concerning the demand articulation support per cluster, that recommend treating the quantitative demand articulation mean score of the biotech cluster with care. For the green biotech sector it was indicated by the CEO of a big seed company that the fundamental knowledge was growing at such a speed that the development of applications cannot keep up and that there is a lack of absorptive capacity at the company level, which triggers the search for technology integrators. The demand for people choosing an education that qualifies them to work in the green biotech sector has been articulated by the green biotech cluster organization, as the cluster organization took on the task of promoting green biotech related education in the region. In the green biotech cluster especially the improvement of the labor market situation and the access to highly trained personnel was stressed by the member companies. *A few years ago, we were happy to receive one application on a vacant position, now we can choose*, was stated by the R&D director of a big company. The positive assessment was also found on the quantitative level where the green biotech cluster scores highest on providing access to highly trained personnel[2].

The relative importance of the different open innovation partners

Before assessing the cluster organization's roles in network formation support, the relative importance of the different open innovation partners in the different clusters is shown in Figure 2.1.

[2] Access to highly trained personel has been included in Table 2.6 under Network formation support, while for the green biotech cluster it is a result of demand articulation support. Since it was decided to only allocate the quantitative indicator to one support function, it is missing in Table 2.5. Further, the qualitative findings support giving the demand articulation function a more prominent role in the electronics and green biotech cluster than in the agrifood cluster.

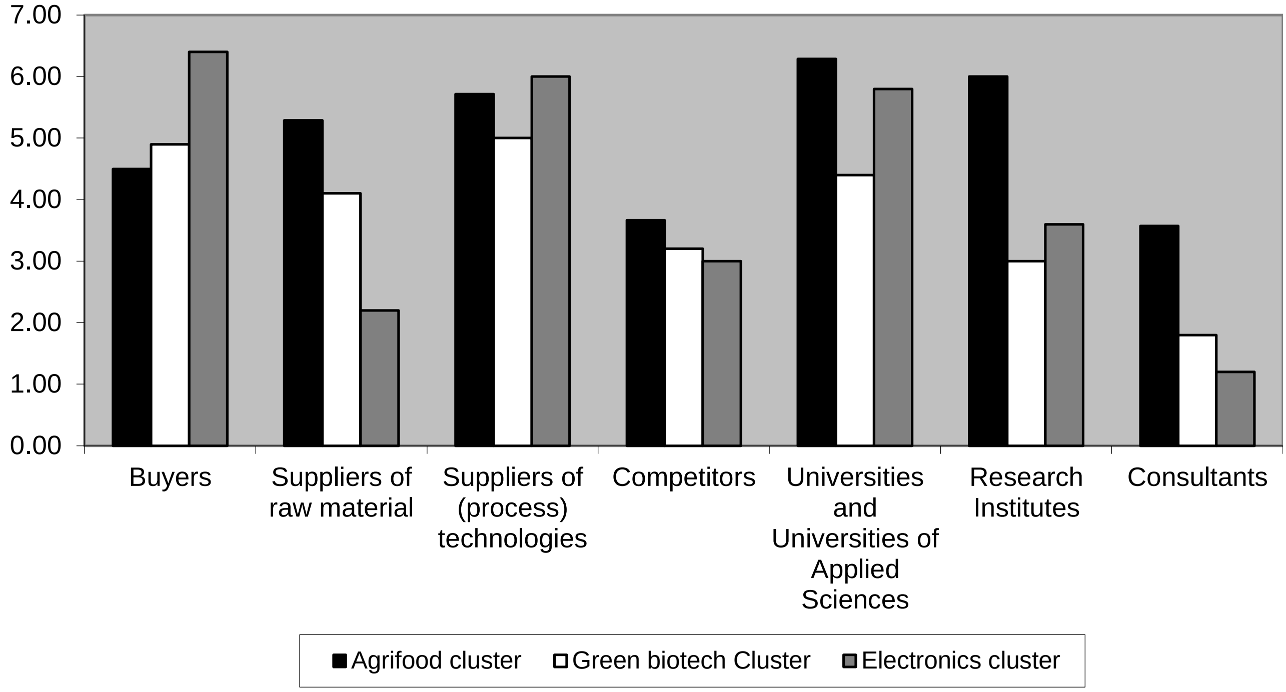

Figure 2.1. Importance of different types of open innovation partners per cluster

The buyers play a prominent role as open innovation partner in the electronics and the green biotech cluster, followed by the suppliers of process technologies and the universities. For the agrifood cluster the order of importance is different. Here the universities take the lead, followed by the research institutes and suppliers of process technology and those of raw material. This order of partner importance supports the classification of the agrifood cluster as regionally networked innovation system in which ex ante and ex post support by the knowledge institutions are regarded as typical. This sets it apart from the two other clusters that are rather regionalized innovation systems. Significant differences were respectively found regarding the importance of universities, research institutes and consultants that were found to be significantly more important in the agrifood cluster, compared to the green biotech and the electronics cluster. In the agrifood and the green biotech clusters the suppliers of raw materials play a more prominent role as open innovation partner than in the electronics cluster, although this difference is not statistically significant due to high standard deviations. In all three clusters cooperation with competitors and consultants is regarded as of the lowest importance. However, in spite of the low preference, competitors were found to be involved in precompetitive open innovation projects in all three clusters.

Seen in the light of the above mentioned fear of the leaking out of confidential information, it was remarkable that in the interviews in all three clusters the non-competitor clause as a protection mode to the leaking out of confidential information was regarded as being of little importance, although almost all companies, except two SMEs, had it in their employees' working contracts. In general, the problem of staff leaving the company to get hired by a competitor was regarded as solved by gentlemen's agreements not to abuse the knowledge imported with new staff. This gentlemen's agreement is based on solidarity, the circumstance that the staff of most competitor companies know each other and that there will be social sanctions in case of abuse.

<ins>*Network formation support*</ins>

Companies in the three clusters were relatively satisfied with the network formation support function of the cluster organization. In all three clusters, the cluster organizations organize so-called matchmaking events such as annual consortium meetings and/or conferences. In order to facilitate matchmaking, the number and choice of attendants to these meetings is regarded as crucial. The cluster member companies see the cluster organization as a pre-selector to specifically introduce people and knowledge to these meetings.

In a number of cases, the cluster organization plays a direct role in linking organizations. Especially the green biotech cluster organization is active in this respect, linking member companies to buyers, suppliers, universities and research institutes. The same holds for the electronics cluster organization that helped linking member companies to process technology providers, universities and research institutes (Table 2.6). These findings are supported by the interviews. The companies in the electronics cluster indicated that the cluster organization played a pivotal role in providing a reliable network for setting up innovation collaborations. In the green biotech cluster the CEO of an SME providing contract research indicated as the advantage of the cluster that it enabled him to get in touch with the CEOs of the big companies, which had not happened before in such an informal way. Another SME CEO called the green biotech cluster even a *contact pool* and *important for developing new ideas.*

Table 2.6. Network formation support

Indicator Question		Mean (Stdv)		
		Agri food	Green biotech	Electronics
Can you indicate where the cluster contributed over the last 3 years?	Setting-up or expanding your network	4.5 (1.5)	4.0 (2.8)	4.8 (1.2)
	Access to highly-trained personnel	4.0 (1.5)	4.4 (1.9)	3.2 (2.1)
Did the cluster organization play a role in establishing cooperation with the following partners? [yes/no]	Buyers	0 %	40%	0%
	Suppliers of raw material	0%	20%	0%
	Suppliers of (process) technologies	14%	20%	20%
	Competitors	0%	0%	0%
	Universities and Universities of Applied Sciences	0%	40%	60%
	Research Institutes	0%	20%	20%
How important was the role of the cluster in achieving:	New cooperative partnerships	2.0 (1.7)	3.3 (2.1)	5.2 (1.1)

In the agrifood cluster the direct network formation support role of the cluster organization was limited to linking to technology suppliers. However, the matchmaking meetings were regarded as very important. The 'members only' society meetings and the annual conference were mentioned to be of special importance for getting inspired by other companies and as a means of network formation. This function was summarized by the statement of the CEO of a technology providing agrifood SME: *We are meeting people that we would not have met otherwise*. In terms of network formation support the borders per cluster are considered differently. In the internationally oriented green biotech cluster, as well as the electronics cluster, the collaboration focus is European and global, which makes them regionalized innovation systems, whereas in the agrifood cluster the innovation matchmaking is mainly done at a national level.

Internationalization support

The mainly national orientation of the agrifood SMEs is also reflected in the special importance of internationalization support (Omta and Fortuin, 2013). Here the agrifood cluster organization takes up the important role of promoting member SMEs products, processes and technologies at a global scale by representing them at international fairs. The internationalization support function is also reflected in the fact that the agrifood cluster organization (and the green biotech cluster organization to a lesser extent) acts as an intermediary that organizes visits of (international) delegations to interested member companies.

2.5 Discussion and conclusions

These results highlight the role of the cluster organization as facilitator providing innovation process, demand articulation, network formation and internationalization support, whereas the company is emphasized as the locus of innovation. Concerning the cluster organization functions the conclusions apply to a number of similarities as well as to a number of differences between the clusters.

Innovation process support

The innovation process support function is to a large extent sector independent, specifically regarding the promotion of the region as an attractive living and working area for highly qualified employees. Differences in level of innovation process support can be concluded to be more related to the actual economic situation of the sector than to the tech level differences or differences in RIS types between the clusters. Overall, the cluster organizations' innovation process support is still rather low while the promotion of the region constitutes a positive exception as part of this function for all three clusters. In all three clusters the perception of innovation process support received differs per interviewed organizations with only a number of SMEs that showed high appreciation for the innovation process support. With the technology and market road mapping the electronics cluster provides a more structured way of enhancing the *alignment and learning of the multi-actor network* (Klerkx and Leeuwis, 2009) compared to the other two clusters.

Demand articulation support

Also regarding the demand articulation support function, technology and market road mapping in the electronics cluster make the difference in *articulating innovation needs and corresponding demands in terms of technology, knowledge funding and policy* (Klerkx and Leeuwis, 2009). In the two other clusters this function is executed in a less formalized way.

Another difference found between the clusters concerns the level and scope of demands that are articulated. The two regionalized RIS's differ here remarkably. While the electronics sector cluster organization articulates mainly subsidy needs related to the technological future of the whole sector, the cluster organization of the green biotech cluster puts the focus on emphasizing educational issues and on land development plans, which means focusing on articulating demands on the regional level.

Network formation support

For all three clusters it can be concluded that the network support function in terms of organizing annual consortium meetings and/or conferences is considered by all companies to be very important. The cluster member companies see the cluster organization as a pre-selector to specifically introduce people and knowledge to these meetings based on invitation. Matchmaking is regarded by the company representatives as an interpersonal business where the formalization possibilities are limited. As the coordinator of the agrifood cluster phrased it: *there is no possibility to really formalize it* and the problem was highlighted even more specifically by the CEO of an SME in the green biotech cluster: *also really bad people can become member of the cluster*. Another CEO formulated it as follows: *For me it is most important to get to know these* [good and bad] *people; the personal level is the most important for building trust*.

Further it can be concluded that in terms of network formation support the borders per cluster are considered differently. In the internationally oriented green biotech cluster, as well as the electronics cluster, the collaboration focus is European and global. Whereas in the agrifood cluster the innovation matchmaking is mainly at a national level.

Internationalization support
Only in the low-to-medium tech agrifood cluster was there a clear need for internationalization support for SMEs to reach foreign markets, while in the green biotech and the electronics sectors the SMEs already acted at European and even global level. It could however also be argued that this finding results from the different type of RIS that the researched clusters constitute, a regionally networked innovation system in case of the agrifood cluster versus two regionalized innovation systems (the green biotech and the electronics cluster). The two regionalized innovation systems had cluster activities executed by virtual organizations based on cluster member staff dedication. This strengthens the bonds between the cluster members, which is not the case for the regionally networked RIS, the agrifood cluster.

For regionalized RISs it can therefore be concluded that the cluster organization executed their functions in a way that made cluster members come closer together again on a number of topics. For the regionally networked RIS it rather executed the cluster organization functions in reaching out beyond the cluster borders.

Merging of the functions
In the electronics sector the impact of the economic crisis was more severe than in the other two sectors and constituted a specific challenge. The electronics cluster organization was the only one to intervene concerning the economic crisis, which can be seen as the crisis management function. This goes beyond the demand articulation, network formation and innovation process support functions as described in the literature. The key to the cluster organization acting as a crisis manager can rather be seen in merging these functions as one support package tailored towards the specific needs originating from the crisis.

The use of different categorization schemes for the cluster types
For the present chapter, dividing the clusters into regionally networked and regionalized RIS helped in explaining the differences in the internationalization function of the cluster organization. The division of clusters into tech levels failed to explain quite comparable levels in innovation importance per cluster. For explaining the differences in the innovation process support function both schemes failed to add explanatory value. Here the goal behind setting up the cluster organization was key to explaining the findings per cluster.

The green biotech cluster is an ex post regionalized innovation system, a constellation that was not considered in the RIS classification system of Asheim and Coenen (2005). The same applies to the electronics cluster which can be regarded as a regionalized innovation system with ex ante and ex post elements concerning the contribution of the knowledge institutions, which is inconsistent with the stereotype described by Asheim and Coenen (2005).

All three clusters, although regarded as focused on one sector, contained companies operating at really different technological levels and can therefore not be treated as simple agglomerations of low-to-medium tech or high-tech companies. The heterogeneity of companies has to be regarded. Therefore a complementary use of both classifications is suggested for further research in order to compare clusters across sectors. Further, an extension of the classification system by including an SME proportion component per cluster should be considered.

Chapter 3

Characteristics of innovation alliances[3]

3.1 Introduction

Policy makers are becoming increasingly aware of the fact that R&D intensive SMEs play a pivotal role in providing sustainable economic growth by maintaining high innovation rates. To compensate for their financial vulnerability, these SMEs increasingly conduct innovation in alliances. A good understanding of the mechanisms that govern such innovation alliances is therefore a prerequisite for an effective innovation policy. The present chapter aims at contributing to our understanding of the dynamics of innovation alliances by exploring the impact of different alliance characteristics on the performance of Dutch biotechnology SMEs. An R&D intensive biotech SME is often the product of an innovative idea; an ad-hoc creation triggered by the presence of a "star scientist" (Zucker and Darby, 1996) following a high-risk strategy that involves cutting edge science (Pisano, 2006). Hall and Bagchi-Sen (2002) found in their sample of 74 biotech companies in Canada (95% SMEs) that 28% of the companies originated from universities and 15% were industrial spin-offs, whereas more than 50% were founded as independent ventures.

Small biotechnology companies are frequently facing resources constraints (Majewski, 1998). Considerable capital investments are needed to pay for specialized staff and equipment to develop new products and processes and to successfully introduce them to the market. This problem is even more pressing because biotechnology companies, especially those related to the health sector, face long time horizons until first revenues begin to pour in, which often makes them not profitable for a long period of time (Denis, 2004). Bagchi-Sen et al. (2011) mention the following barriers to innovation: *lack of skilled managers or researchers, a lack of physical facilities for research or manufacture, as well as a lack of marketing or distribution channels.* Biotechnology firms may suffer from resource constraints, but at the same time they generally have a lower bureaucratic burden. They are usually considered to be more flexible and therefore better innovators. Unique competencies, a low level of hierarchy and a high internal flexibility (Nooteboom, 1994, Pisano, 2006) make up for their lower financial power (Argyres and Liebeskind, 2002). A general overview of the advantages and disadvantages of SMEs, not limited to the biotech sector, is provided in the literature review of Ebrahim et al. (2010), while Khilji et al. (2006) conducted exploratory research specifically on the challenges of biotech SMEs.

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[3] This chapter is based on the publication: Garbade, P.J.P., S.W.F. Omta and F.T.J.M. Fortuin, (2013). Exploring the characteristics of innovation alliances of Dutch Biotechnology SMEs and their policy implications. *Bio-based and Applied Economics*, 2(1), 91-111.

Mangematin et al. (2003) found in their study of 60 French biotech SMEs an average growth rate of 30% in turnover and 13% in staff. Still, only a small number of biotech firms grow into reasonably large companies, especially those companies that have learned to engage in collaboration projects with a heterogeneous set of partners *(Powell et al., 2005)*. The forming of alliances as an effective tool to overcome the problems of limited resources was also found in a study of Rothaermel and Deeds (2004) on 325 health related biotechnology companies. Strategic alliances constitute a powerful strategy for biotech firms to overcome their capital constraints (Khilji et al., 2006) and are found to accelerate innovation (Terziovski and Morgan, 2006). Alliances allow access to missing competences and material resources and thus enhance the innovative potential and firm performance (Hall and Bagchi-Sen, 2002, 2007). However, Khilji et al. (2006) indicate that not enough is known on how to successfully manage a strategic alliance. Pisano (2006) remarks that business models, organizational strategies and approaches from other high-tech sectors have been used while not taking into account the special characteristics of the biotech sector, and that *organizational and institutional innovations are needed to unlock the potential of biotechnology*.

The high level of innovativeness of the biotech sector, combined with the high level of alliance formation, makes it an ideal sector to study the critical success factors for collaborative 'open' (Chesbrough, 2006) innovation. To date, a number of empirical studies have been carried out to study alliance collaboration in this sector. They focus on the company performance related to the alliance portfolio (see Baum and Silverman, 2004, George et al., 2001), the network composition and dynamics (Gay and Dousset, 2005), or the alliance duration in an uncertain environment (Pangarkar, 2003). The alliance collaboration process concerning knowledge management (e.g. Nooteboom et al., 2007, Standing et al., 2008), alliance capabilities (Heimeriks and Duysters, 2007) and governance (Phene and Tallman, 2012) are also the focus of more recent studies. However, a literature review (not only on biotech alliances) done by Comi and Eppler (2009), still highlighted a lack of research on alliance management, especially in start-up biotech companies.

The objective of the present chapter is to fill this gap by studying the alliance collaboration process to explore the attributes of both successful and less successful innovation alliances among biotech SMEs. This will allow the improvement of policy support focusing on alliance collaboration process. To this end, different types of alliances, that were set up to carry out joint open innovation projects (in the remainder of this book termed 'innovation alliances'), are investigated and their effect on the alliance potential, alliance execution and the alliance performance is mapped.

The remainder of Chapter 3 is organized as follows: Section 3.2 contains the theoretical framework. In this section the discussion of the resource based view (RBV) will lead to the conceptual model in which the concepts relevant for this research and their relationships are identified. At the beginning of Section 3.3 the operationalization of the constructs is presented. Section 3.3 also discusses the methods of data collection and data analysis. Section 3.4 starts with the baseline description of the participating companies and their alliances. Next, the results are analyzed using partial least squares, while comparing the theoretically expected results with the empirically model. In Section 3.5 the main conclusions are drawn.

3.2 Theoretical framework

In management literature it has been argued that strategic technology partnering can induce the effective use of heterogenic resources (Hagedoorn, 1993, Powell et al., 1996, Ahuja, 2000, Rowley et al., 2000, Rosenkopf and Almeida, 2003). As introduced in Section 1.3.2, a better understanding of this phenomenon is achieved by application of the RBV(Barney, 1991, Alegre et al., 2011). RBV is based on two fundamental assumptions: companies in an industry do not all possess the same resources which provides resource heterogeneity, whereas the partial immobility of these resources preserves this state of disequilibrium (Barney, 1991). Following the line of thought of the RBV, an alliance is a tool to (partly) overcome the problem of the immobility of resources by creating a new entity with a unique set of resources. Nooteboom et al. (2007) claim that while the antecedents of resource heterogeneity and the consequences for the firm's innovation performance have been studied, the direct effects on the innovation process have largely been ignored. Nooteboom et al. (2007) fills this gap by shedding light on the causal factors underlying the inter-firm learning process, especially with regard to the cognitive distance between firms. This chapter aims at taking Nooteboom et al. (2007) 's conceptual idea a step further, by looking at alliance formation and execution from a process perspective. This is done by modeling the collaborative open innovation process for which the alliance is set up: from the potential of the alliance for the participating companies via the alliance execution to the final alliance performance phase.

3.2.1 Conceptual model

The model developed for the present study conceptualizes the alliance as a collaborative entity created by two or more companies in order to innovate. Several factors that are expected to play a role in the innovation alliance collaboration process have been identified. These factors and their assumed relationships are presented in the conceptual model in Figure 3.1. The different constructs are discussed per alliance phase in Section 3.2.2 - 3.2.4.

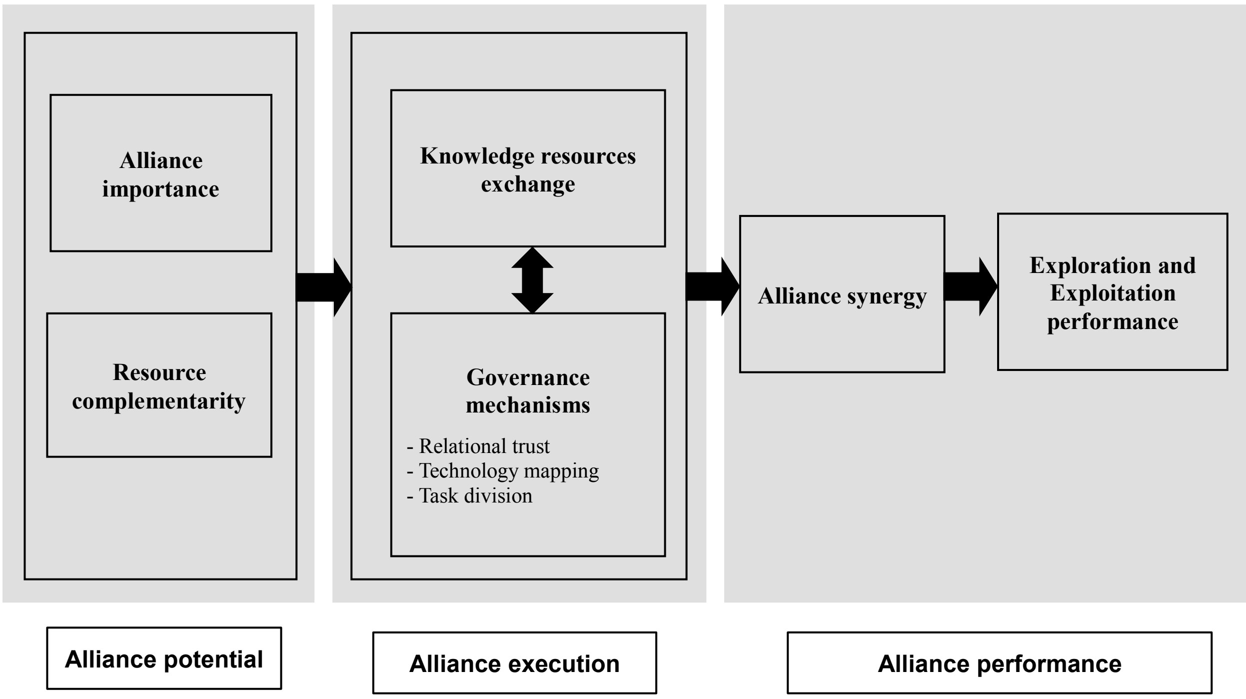


Figure 3.1. Conceptual model

In the 'alliance potential' phase, preceding the actual start of an alliance, potential partners have to be identified. Alliance potential is defined as the innovation possibilities originating from the total set of resources available to the partners engaging in an alliance. Each potential partner has not only its own distinct set of material and immaterial resources, but might also have a different expectation of what it might gain from the alliance. The decisions made in the selection process set the stage for the alliance, and determine the alliance potential. After this has been decided, the 'alliance execution' phase can start. During this phase, resources are exchanged among the partners to develop new products and processes. Depending on the extent to which the alliance potential could be exploited through well-executed alliance formalization and execution phases, different levels of alliance performance are expected.

3.2.2 Alliance potential

In the phase preceding the actual start of an alliance, potential partners have to be identified. Each potential partner has not only its own distinct set of material and immaterial resources, but also a different expectation of what it might gain from the alliance. The decisions made in the selection process set the stage for the alliance, and determine the alliance potential. The following factors were identified as determinants for the alliance potential: alliance importance and resource complementarity.

<u>Alliance importance</u>

The intentions and motivation to turn an alliance into a success are expected to play an important role in alliance performance. The more partners expect to benefit from the alliance, the more they are likely to invest in it. This factor is termed 'alliance importance'. The importance status of an alliance refers to the strategic importance of an alliance for a company to achieve its goals. An alliance is consequently ranked in terms of priority compared to the other alliances in which the company is engaged, as well as compared to the other activities of the company. Since it is assumed that scarce company resources are allocated according to the highest expected returns, the amount and value of resources dedicated to an alliance should reflect its assumed importance for the company. In Table 3.1 the alliance importance is therefore indicated by the number of company staff taking part in the alliance collaboration. It is expected that a high level of importance attached to the alliance will be positively related to alliance performance.

<u>Resource complementarity</u>

Each potential partner has its own distinct set of material and immaterial resources. The decision has to be made whether to search for partners with similar or complimentary resources. By combining similar resources, economies of scale and scope (Ansoff, 1965, Montgomery, 1985), whereas an alliance with a partner that has complementary resources synergy effects might be obtained (Harrison et al., 2001). According to RBV, alliances can be considered as tools to create new unique sets of resources that enable the partnering firms to (partly) overcome the immobility problem of certain resources. It is therefore assumed that the potential of an alliance will be positively influenced by the level of complementarity of the resources that are brought into the alliance by the partnering companies and the extent to which these are exchanged. Complementary resources deliver learning opportunities and allow the creation of new capabilities (Harrison et al., 2001). Harrison et al. (2001) proved complementary resources to play a major positive role in strategic alliances. Chesbrough (2006) also stresses the importance of complementary resources for open innovation projects. So, with the choice of partners, the focal company determines how far its material and immaterial resources will be complimented by those of the partner(s). However, selecting partners with complementary resources only makes sense if the partners are able to understand each other's knowledge contribution. Indeed, Park and Russo (1996) found that joint ventures that used complementary resources failed more often than expected. An explanation for this finding might be found in the work of Cohen and Levinthal (1990), who point at the importance of absorptive capacity; defined as a company's capability to recognize the value of new information, its ability to assimilate it and to apply it to commercial ends. Absorptive capacity is dependent on information redundancy or as Nonaka (1994) states: ' *Only individuals sharing overlapping information can sense what the others are trying to articulate'* . It is therefore expected that when the research domains of the partners and the range and methods used (termed 'cognitive distance' by Nooteboom (2000)) are too far apart, the level of absorptive capacity will decrease and with this the synergy potential of the alliance. Indeed Nooteboom et al. (2007) found that there is an optimum cognitive distance in alliances.

3.2.3 Alliance execution

During the alliance execution phase knowledge is transferred and utilized to develop new products and processes. The following factors were identified as essential elements to characterize the quality of project execution: knowledge resources exchange, relational trust, technology mapping and task division.

Knowledge resources exchange

When it comes to knowledge management a distinction is made between knowledge creation, transfer and application, while all three processes are interrelated (Meier, 2011, Harryson et al., 2008). Also a distinction is made between inter- and intra-organizational knowledge exchange (Van Wijk et al., 2008). In an innovation alliance both types of knowledge exchange are considered key elements of the collaboration process (e.g. Nooteboom, 2000, Grant and Baden-Fuller, 2003). Knowledge resources exchange (also called 'knowledge transfer') is defined as a *transmission process whereby existing knowledge is transferred within or across firm boundaries* (Meier, 2011, Collins and Hitt, 2006), while different phases of knowledge exchange can be distinguished (Easterby-Smith et al., 2008, Harryson et al., 2008, Van Wijk et al., 2008). Nonaka (1994) identifies two forms of knowledge: explicit and tacit knowledge, and four ways in which knowledge can be exchanged: from explicit to explicit, from explicit to tacit, from tacit to explicit, and from tacit to tacit. The tacit knowledge resources exchange is rather difficult since it is *(1) non-verbalizable, context specific and personally bounded, and (2) alliance partners are reluctant to transfer such knowledge freely to the alliance partner, as it is perceived as particularly valuable* (Meier, 2011). While explicit knowledge is stored in codified form and can be exchanged through documents, tacit knowledge requires human interaction to transfer i.e. through shared experience (Nonaka, 1994). Nonaka and Von Krogh (2009) therefore recommend human resource exchange as an effective way to transfer knowledge because it implies a flow of information comprising both tacit and explicit knowledge. Ambiguity of knowledge provides an additional burden (Van Wijk et al., 2008) that only human interaction can resolve. Therefore also mutual support in terms of management, coaching and training is assumed to lead to knowledge exchange between the alliance partners.

Governance mechanisms

Nooteboom (2000) provides a literature review on the problems in governing knowledge resources exchange. He lists the notion of "hostages", redistribution of ownership of specific investments, balance of mutual dependence, and reputation mechanisms as possible governance mechanisms to deal with these problems. In Chapter 3, the research focus is on the impact of relational trust, technology mapping, with mutual dependence, and outsourcing of certain innovation activities which encompasses the (re) distribution of ownership.

Relational trust

Low relational trust is a factor that can crush the expectations resulting from the alliance potential assessment. Issues like trust and cooperation within high tech alliances are found to be positively related to human resource exchange practices (Collins and Hitt, 2006). The level to which partners adhere to the agreements made before the actual start of the innovation alliance (termed 'alliance compliance') is expected to play an important role by creating the trust and spirit of cooperation necessary for the smooth execution of the collaborative open innovation project. If there is no relational trust due to opportunism, missing coordination of company actions knowledge resources exchange might be lowered. In a company collaboration context this also means that the process of transforming tacit into explicit knowledge slows down or even stops.

Technology mapping

Intellectual Property (IP) is important in alliances in which the partners work closely together to reach certain innovation aims and objectives. IP management is connected to terms like, IP valuation, IP licensing, IP preparation for sale, detection of infringements, and use of IP intermediate markets (Chesbrough, 2006). To secure the ownership of IP after a completed discovery is a big issue and is becoming even more challenging in the world of open innovation, where "*technologies flow across the boundary of the firm"* (perhaps multiple times) and where "*obtaining the ability to practice a technology without incurring an infringement action by another* *firm is more challenging because the full history of the technology development is well known*"(Chesbrough, 2006).

Patents are often used to protect knowledge from being stolen, provide a possibility to legally own it and make it tradable. Patents also indicate the value as a network partner as shown by the research of Smith-Doerr et al. (1999) on biotechnology firms.

Patents reduce the risk of infringement but only if all of the knowledge used in the technology application is included in that patent, or possibly in several patents. So to prevent infringements patent mapping is unavoidable. Patent mapping checks for all of the granted claims of a patent that is owned by the company and looks also at possible claims that could arise from other patent holders (Chesbrough, 2006). This might lead to efforts to obtain possession of patents that are holding key positions in the innovation process of the company or the alliance. In order to reduce the risk of exploring without being able to exploit, one should think of starting patent mapping already early in the innovation process. This reduces the risk of being left with a discovery at the end of the innovation process that cannot be exploited. In an innovation alliance there is also the possibility that the alliance partners look at each other's patents in order to investigate their potential. In a study about Canadian biotechnology start-ups, Baum et al. (2000) found alliances that *provide access to more diverse information and capabilities per alliance .... will prove most beneficial to startups*. So resources exchange in the form of IP may be enhanced by letting the alliance partner having a closer look at the patents in store or at technologies with no patents or no patents granted yet. This is also the reason why the use of the term technology mapping is preferred in the present chapter. Its meaning is extended beyond the IP protection aspect and focus also on using it as an alliance internal communication tool, and consequently, also as a governance mechanism to transfer knowledge. By mapping the different technologies used in an alliance in a shared document, explicit knowledge as well as redundancies are created. This will help to understand each other's knowledge domains (e.g. Nooteboom, 2000) and since tacit knowledge is turned into explicit knowledge, alliance coordination is simplified.

Task division

Complementary resources possess the potential to enhance synergy. In cases where knowledge is easy to transfer this process is straight forward. However, in cases where the complexity of matching complementarity resources is high, this could lead to hold up (Nooteboom, 2000). The way to synergy creation might then go via a clear task division between the alliance partners, also lowering coordination costs.

3.2.4 Alliance performance

In industry, performance can be assessed at the innovation process level (innovative performance) and at the industrial outcome level (industrial performance, Omta and De Leeuw (1997)). Since the research process takes place within an alliance, the innovative performance is assessed at the alliance level. Alliance performance in the present chapter therefore focuses on the output resulting from the collaboration. Next to the direct results in terms of new products and processes, this could be new contacts, a better reputation within a network, or a new line of thinking. All of these outcomes may lead to a higher potential of future alliances with current or other partners and therefore demands a dynamic model. However, for the present chapter, the choice was made to look at the alliance at one point in time. Therefore the output focus lies on the synergy created and in how far the alliance resulted in new knowledge (inventions) and new products and processes (innovations).

Alliance synergy

Synergy describes a situation where the final outcome of a system is bigger than the sum of its parts. This can be found in an alliance in the form of new knowledge that surmounts the knowledge input that was brought into the alliance from both alliance sides as well as to new processes and technologies resulting from the alliance.

Exploration and Exploitation performance

Alliance performance covers exploitation performance and exploration performance, where exploitation is concerned with the refinement and extension of existing technologies (Lavie and Rosenkopf, 2006) and exploration is rooted in the extensive search for potential new knowledge (March, 1991).

The theory leads to the following general hypothesis: *Innovation alliances that show a higher level of complementarity and overcome cognitive distance with intense knowledge resources exchange lead to the creation of synergy and ultimately to a higher level of innovation performance.*

3.3 Methods

Table 3.1. Operationalization of constructs

Construct		AVE Average Variance Extracted	Composite reliability	R^2	Cross Loading	**Indicator Questions** operationalized using 7-point Likert scales from 1 (not at all) to 7 (to a very large extent)
Alliance importance		1	1	_*	1	*Number of staff of your company involved in the alliance*
Resource complementarity		0.74	0.89	_*	0.85	*To what extent does the expertise your company possesses differ from your alliance partner?*
					0.86	*To what extent does the research field your company operates in differ from your alliance partner?*
					0.87	*To what extent are the patents you possess located in a different research field?*
Knowledge resources exchange		0.59	0.81	0.44	0.74	*This alliance partner supports in management coaching and training.*
					0.79	*This alliance partner exchanges human resources with you.*
					0.78	*The exchange of human resources in this alliance is important.*
Governance mechanisms	***Relational trust***	0.74	0.85	_*	0.91	*In this alliance opportunism was not a problem.*
					0.80	*In this alliance coordination was not a problem.*
	Technology mapping	1	1	0.41	1	*Extent of technology mapping used in this alliance.*
	Task division	0.72	0.84	_*	0.90	*Activities outsourced to the partner due to restrictions of company apparatus.*
					0.80	*Activities outsourced to the partner due to restrictions of company skills.*
Alliance synergy		1	1	0.12	1	*Please give the synergy created due to this alliance.*
Exploration performance		1	1	0.61	1	*Due to this cooperation new knowledge was generated.*
Exploitation performance		0.71	0.83	0.38	0.91	*Due to this alliance products were developed, that were new to the market.*
					0.78	*Due to this alliance production processes were created or significantly improved.*

* - for the independent constructs, with no predicting constructs, no R^2 can be calculated

For the empirical test of the model a two-step approach was chosen. Firstly the constructs used in the model were operationalized. Then the respondents were given the survey to answer the indicator questions on a Likert scale of 1 ("not at all") to 7 ("to a very large extent"). The detailed items used to measure each construct are listed in Table 3.1.

For the present study a sample was composed of firms active in the Dutch biotechnology sector. Eighteen SMEs participated in the study, reporting about 40 alliances. The sample was composed of biotech firms active in the Dutch high-technology life sciences sector, with a special focus on explorative biotechnology alliances. To create a certain level of homogeneity, firms had to fulfill the following criteria to be included in the sample: dedicated life sciences firms; geographically located in the Netherlands; owned by a Dutch entrepreneur or management team; originally founded as a life sciences firm (thus excluding firms that changed their business focus to life sciences only in a later stage); not traded on the stock market; not a multinational firm; still up and running at the time of surveying. This resulted in the identification of 120 firms that could be included in the study sample. These firms received an invitation to participate in the study, combined with the final version of the questionnaire. Eighteen firms agreed to participate in the study, a response rate of 15%. These firms reported 40 alliances.

The decision which statistical tests would be applied, the scaling of the data as well as the number of answers given had to be taken into consideration and excluded a number of statistical procedures. Partial Least Squares (PLS) software (Ringle et al., 2005) was used to model the alliance collaboration process and to test the hypothesis. *PLS delivers construct scores, i.e. proxies of the constructs, which are measured by one or several indicators* (Henseler et al., 2009). PLS is a causal modeling approach, developed by World in 1975 and applicable in strategic management research (Hulland, 1999). *PLS is similar to regression, but simultaneously models the structural path* (i.e. theoretical relationship among constructs) *and the measurement path* (i.e. relationship between a construct and its indicators, (Chin et al., 2003). The procedure enables the modeling of constructs and gives more accurate estimates of interaction effects between constructs, as it takes the measuring errors in the underlying indicators into account.

PLS shows the significant effects of the different constructs on each other, while every construct itself is reflected by its indicators (measures). With the help of PLS (a series of ordinary least squares) the constructs are estimated as linear combinations of its measures, by maximizing the explained variance for the indicators and the constructs. As a result the construct is not only maximally correlated with its own set of indicators, but also with the other constructs, according to the structure of the PLS model (Chin et al., 2003). *Although Partial Least Squares (PLS) can be used for theory confirmation, it can also be used to suggest where relationships might or might not exist and to suggest propositions for later testing (Chin and Newsted, 1999)*. Marcoulides and Saunders (2006) warn researchers not to use PLS as a "silver bullet" while Hair et al. (2011) specify under which conditions PLS might indeed be a silver bullet. For the decision to apply PLS, the scaling, the number of cases and distribution of the data has to be taken into consideration. In contrast to LISREL, PLS can deal with small samples, depending on the complexity of the model and the size of the effects to be detected (Chin and Newsted, 1999), and doesn't require a normal distribution of the data (Chin et al., 2003). The significance of the interaction effects uncovered with PLS was tested with bootstrapping, a cross-validation method. It is a resampling procedure, which yields the same number of cases as in the original sample. As the bootstrapping is based on trial and error it gives slightly different results every time it is used for the same model. The number of resamples was chosen to be 1000 exceeding the 200 indicated as minimum by Chatelin et al. (2002).

The Kolmogorov Smirnov Z test was used to find differences between pharmaceutical related and agrifood related alliances and the Kruskal Wallis exact test was used to identify mean differences between the alliances stated by different companies of different size and location categories.

3.4 Results

3.4.1 Baseline description

The hypothesis was tested analyzing 40 alliances of 18 SMEs in the Dutch biotechnology sector. Of the companies that answered the questionnaire, 6 have business activities in diagnostics, 6 in therapeutics, 3 in food and neutraceuticals and 6 in plants and seeds biotechnology. The majority of the SMEs are product oriented, with products such as biomarkers for cancer treatment, but also microbiological products related to food safety and breeding. Fourteen SMEs are located in different clusters or cluster like set-ups, such as incubator centers, university campuses or business parks (Table 3.2), while 4 companies are not connected to a company agglomeration. The cluster or cluster like set-ups are spread all over the Netherlands[4]. They are frequently headed by a coordinating organization, and financed by membership fees of the participating companies and/or public money. These coordinating organizations provide network formation, demand articulation, internationalization and innovation process support (Omta and Fortuin, 2013). They do so by organizing consortium meetings and annual conferences, providing matchmaking opportunities for member companies (network formation support), issuing (web-based) innovation alerts and providing information about marketing trends (demand articulation support), representing the member companies at international fairs and organizing business missions (internationalization support), and stimulating facility sharing and organizing of special workshops to enhance innovation management (innovation process support).

The SMEs organized in science parks or university campuses indicated possessing the highest alliances performance levels. SMEs not related to bioscience parks or clusters described fewer complementary resources, fewer synergistic effects, and used task division to a lesser extent. Furthermore, they allocated a smaller level of relative importance to resource exchange, and especially to human resources exchange. Their alliance performance levels were lower compared to the other alliances in our study, although they indicated they faced opportunism problems to a lesser extent.

Table 3.2. Demographics of SMEs (n=18) and their alliances (n=40) in the present study.

	SME	Alliances
Bioscience park, university campus*	7	**16**
Clusters**	7	**15**
Not related to bioscience parks or clusters	4	**9**
	18	**40**

* Leiden Bioscience Park, Utrecht Science Park, Amsterdam Science Park, Maastricht Biopartner Center, Eindhoven TU, Food Valley NL, Health Valley, Seed Valley

Eleven companies employ 2 to10 full time employees, while six companies employ 10 to 30 employees, and one company even has 113 employees. Mangematin et al. (2003) found differences

[4] The Leiden Bioscience Park (www.leidenbiosciencepark.nl) around Leiden University includes more than 70 member companies, the Science Park Amsterdam (www.scienceparkamsterdam.nl) around the University of Amsterdam and the 'Vrije' University of Amsterdam consists of around 70 companies, and Science Park Utrecht (www.utrechtsciencepark.nl) around the University of Utrecht, more than 60 companies. In the North of the Netherlands we find Seed Valley: (www.seedvalley.nl) a cluster of 22 breeding companies, located at one of the world's largest plant breeding areas. The Food Valley cluster, around Wageningen University, is coordinated by Food Valley NL (www.foodvalley.nl) and has more than 100 member companies. About 30 km to the South is the core of the HealthValley cluster (www.health-valley.nl), which is located around Radboud University Nijmegen, with around 100 member companies. In Eindhoven, located in the South East of the Netherlands, lies the high-tech campus of the University Eindhoven (www.tue.nl) with 108 companies located on it. Further to the East on the German border we find the BioPartner Center Maastricht (www.bpcm.nl) located on the Health Campus of the University of Maastricht with 22 companies.

in their study on 60 French biotech SMEs between the slightly smaller SMEs (around 10 employees) with small innovation projects targeting niche markets and the slightly bigger SMEs (around 30 employees), which focused on radical innovation projects and grew faster than the first type (Mangematin et al., 2003). Also in the present study a number of differences were found related to the size of the company. The companies with 10 to 30 employees indicated a higher number of staff involved per alliance, older alliances, used technology mapping to a lesser extent and stated a lower alliance performance level, compared to the smaller firms and the very big firm.

The 40 alliances which are the focus of our analysis are split into 26 health-related alliances in 12 companies, and 14 agrifood related alliances between 6 companies. The most important alliance partners were knowledge institutions (in 40% of the cases), big pharmaceutical and chemical trusts (in 15%), other biotech SMEs (in 18%), and non-biotech firms, such as manufacturers (in the 27% of the cases). The sample is dominated by research consortiums and strategic alliances but also includes two informal partnerships. As primary reasons for starting the alliance, increasing innovation and the use of complementary technologies was mentioned most often, followed by the increased access to funding and markets. Thirty of the 40 alliances involved 1 to 3 persons from the companies that answered the questionnaire. In 8 alliances, 3 to 10 persons were involved and in two alliances the number of employees involved was not given. In 30% of the alliances more than 2 companies were involved. The ages of the alliances were equally distributed from 1 to 7 years. There were some differences between the groups of health-related and agrifood-related alliances that were able to be uncovered by using the Kolmogorov-Smirnov Z test. Among the health-related alliances, more technology was licensed out to the alliance partner(s), and a smaller resource complementarity characterized these alliances. The agrifood related alliances scored higher when it came to complementary resources and also with regard to the number of new products or processes that were created and improved in the alliance.

3.4.2 Model specification

First the relation between the sample size and the number of constructs in our empirical model and the way in which the indicators are connected to the constructs are discussed. Then the validity and reliability of the model are assessed. Considering the sample size of 40 innovation alliances the necessary condition that the number of cases at least exceeds the number of indicators (Haenlein and Kaplan, 2004) holds. Also the criterion that the sample size should be 10 times the number of arrows, pointing at the dependent construct with the largest number of constructs influencing it (Chin and Newsted, 1999) is met. In this case it is the dependent construct knowledge resources exchange that is influenced by four constructs (Figure 3.2). What can be criticized is the sometimes small number of indicators per construct. This is a management research problem in PLS, where researchers rarely have more than a handful of indicators per unobservable variable at their disposition (Baumgartner and Homburg, 1996). In some cases it was also decided to ask questions on a higher aggregate level for reliability reasons, while there is obviously then a trade off with the number of indicators available per construct. The indicators are connected to the constructs in a reflective manner for several reasons. First the use of a formative set-up *would define* (or 'cause') the construct and *a defined construct is completely determined by a linear combination of its indicators* (Hulland, 1999). This is not the case for the constructs included in the conceptual model. Instead the underlying constructs are 'causing' the observed indicators, which makes it according to Hulland (1999) a reflective relationship. Second, the included indicators are exchangeable, as there are in general more indicators generated with the questionnaire, than are finally employed in the model. This also implies that the same constructs used in Chapter 3 and Chapter 4 do not necessarily have the exact same indicators reflecting the construct (Table 3.1 and Table 4.1). Third, it can't be excluded that there are measurement errors, which makes the reflective indicators preferable to the formative (Huber et al., 2007). This leads to the following validity and reliability assessments as will be described in Section 3.4.3 and 3.4.4.

3.4.3 Measurement model

Hulland (1999) suggested a general methodology for applying PLS on management issues. First, the reliability and validity of the measurement model has to be assessed before the structural model can be examined and path coefficients interpreted (Hulland, 1999). The measurement model consists of the constructs and the indicators connected to them. Its reliability and validity is assured by verifying individual item reliability, the convergent validity of measures associated with the individual constructs, and the discriminant validity.

Individual item reliability

To measure individual item reliability, the cross-loadings between the indicators and the constructs were checked. Every indicator should, in relation to its construct, have a cross loading higher than 0.7, and indicators to which constructs are not connected should never receive high cross-loadings than those to which they are (Hulland, 1999). The cross-loadings of the indicators generated here fulfill these requirements (Table 3.1).

Convergent validity

To assess the convergent validity of the measurement model a choice can be made between Cronbach's alpha and the Composite Reliability, as developed by Fornell and Larcker (1981). Nunnally et al. (1978) suggests 0.7 as a benchmark and according to (Hulland, 1999) it can be used as a cut-off point for both measures. As Cronbach's alpha tends to underestimate the internal consistency in PLS path models (Henseler et al., 2009), the Composite Reliability was used to measure the convergent validity of the constructs in the present chapter. These were all above 0.7 (Table 3.1).

Discriminant validity

The traditional methodological complement to convergent validity is discriminant validity, which represents the extent to which measures of a construct differ from measures of other constructs in the same model (Hulland, 1999). By making use of the variance the construct shares with its indicators, compared to the variance it shares with the other constructs, the discriminant validity can be assessed by using the AVE (i.e., the average variance shared between a construct and its measures). The square root of the AVE should be higher than the construct correlations. Table 3.3 shows that this requirement is also met.

Table 3.3. Construct correlations

		1	2	3	4	5	6	7	8	9	$\sqrt{AVE}$
1	Alliance importance	1									1
2	Resource complementarity	-.11	1								0.86
3	Knowledge resources exchange	.36*	.27	1							0.77
4	Relational trust	-.20	.03	.15	1						0.86
5	Technology mapping	.07	-.53**	-.37*	-.32*	1					1
6	Task division	.22	-.12	.41**	-.13	.14	1				0.85
7	Alliance synergy	-.14	.06	.03	-.23	.29	.34*	1			1
8	Exploration performance	.19	.28	.56**	-.13	-.08	.38*	.56**	1		1
9	Exploitation performance	.00	-.11	-.18	-.21	.51**	.31	.48**	.25	1	0.85
$\sqrt{AVE}$		1	0.86	0.77	0.86	1	0.85	1	1	0.85	

* Correlation (Pearson) significant at alpha = 0.05 level (two tailed)
** Correlation (Pearson) significant at alpha = 0.01 level (two tailed)

3.4.4 Structural model

To what extent the path coefficients can be trusted depends on the significance level, verified by the t-values (Huber et al., 2007) that are generated with the bootstrapping procedure. For the present model most path coefficients are significant at an $\alpha = 0.05$ level (two tailed), except two path coefficients that are significant with a likelihood of mistake of 0.07 and 0.1. The significance of estimated coefficients in the structural model can be seen in the t-values of Table 3.4. The extent to which the endogenous constructs are explained by the exogenous constructs in the model can be determined on the basis of the R^2 values (Table 3.1), wherein R^2 values of 0.67, 0.33, and 0.19 (with regard to PLS path models) are seen as substantial, moderate, and weak, respectively (Chin, 1998). The PLS model has been checked for common method bias following Podsakoff et al. (2003) by applying Harman's single-factor test (1976) using principal axis factoring (Harman, 1976). Common method variance was not a problem since items loaded on multiple factors and one factor did not account for most of the covariance. Because the model was specified based on our hypothesis before the data were collected, the sample data were used to test the hypothesis only, and not to determine the structure of the model itself. Consequently there was no need for any further model validation (Kumar, 2010).

Table 3.4. Significance of the estimated coefficients in the structural model

	Path coefficients	T statistics
Alliance importance -> Knowledge resources exchange	0.37	2.05*
Resource complementarity -> Knowledge resources exchange	0.35	3.05**
Resource complementarity -> Technology mapping	-0.46	3.27**
Relational trust -> Knowledge resources exchange	0.27	1.87
Relational trust -> Technology mapping	-0.28	2.03*
Task division -> Knowledge resources exchange	0.41	2.99**
Task division -> Alliance synergy	0.34	2.04*
Knowledge resources exchange -> Exploration performance	0.54	5.24***
Knowledge resources exchange -> Technology mapping	-0.20	1.70
Technology mapping -> Exploitation performance	0.40	3.50**
Alliance synergy -> Exploitation performance	0.37	2.58*
Alliance synergy -> Exploration performance	0.55	6.76***

*= significant with a likelihood of mistake ≤ 5 percent, two tailed
**= significant with a likelihood of mistake ≤ 1 percent, two tailed
***= significant with a likelihood of mistake ≤ 0.1 percent two tailed

3.4.5 Construct relations and hypothesis testing

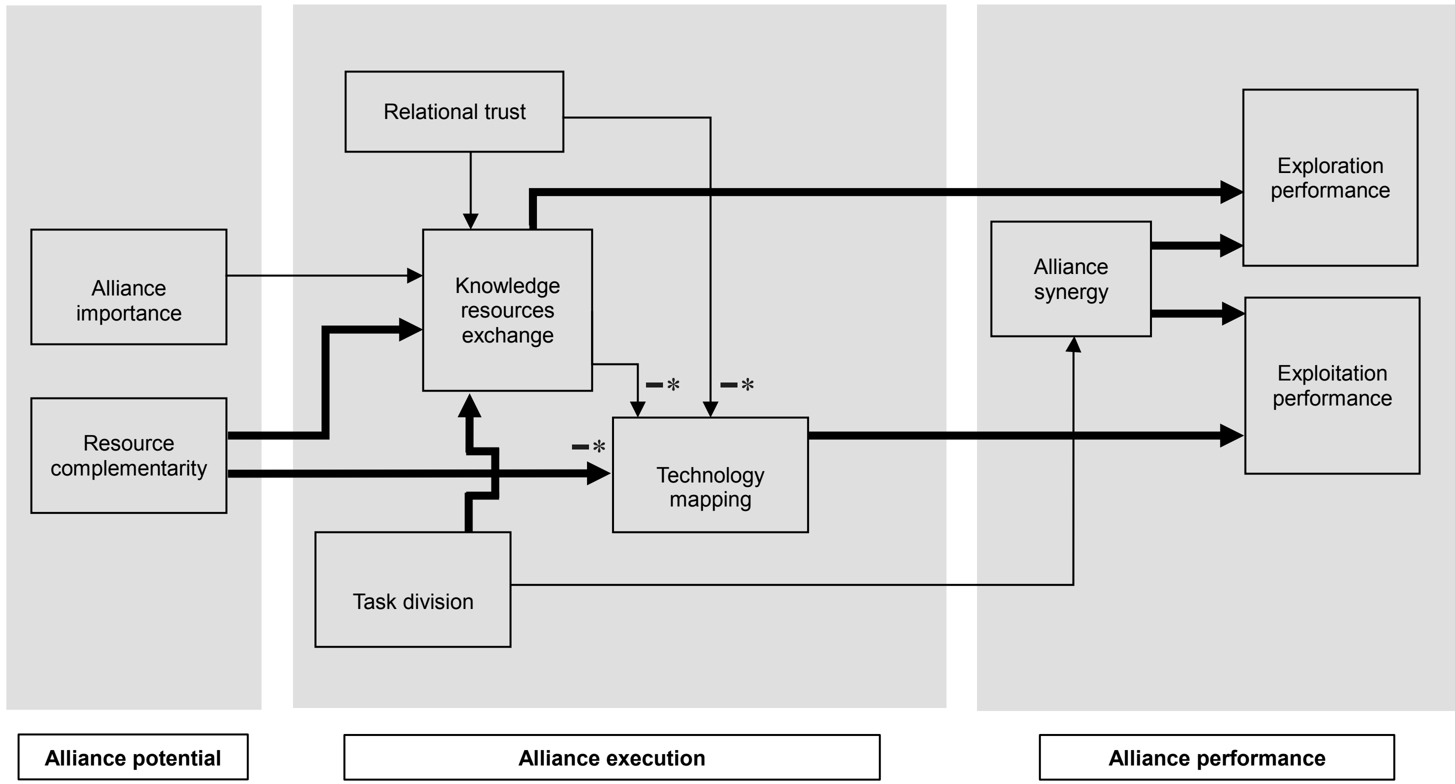
The main hypothesis: *Innovation alliances that show a higher level of complementarity and overcome cognitive distance with intense knowledge resources exchange lead to the creation of synergy and ultimately to a higher level of innovation performance,* holds true as the significant path coefficients in the PLS model indicate. The central role of knowledge resources exchange predicated upon human resource exchange becomes visible through the model. The positive path coefficient from resource complementarity leading to knowledge resources exchange and from knowledge resources exchange directly to exploration performance underscores that human resource exchange is the primary way of exchanging and converting both explicit and tacit knowledge.

Negative path coefficients are found from relational trust to technology mapping, from resource complementarity to technology mapping, and from knowledge resources exchange to technology mapping. This effectively translates into: in cases of low relational trust, a low level of resource complementarity (related to a small cognitive distance) and a low level of knowledge resources exchange, a higher use of technology mapping is also found. The interdependence of these constructs can be explained as follows: To avoid opportunistic behavior, there is a clear need to put the technological contribution from each partner on paper, using technology mapping in order to create a common shared vision of this. The same holds in case of a smaller cognitive distance where it is even more likely that the partners doubt who is contributing what, and where concerns over becoming deprived of similar IP is higher than in alliances with a higher cognitive distance, i.e., where the knowledge/IP contribution is clearer from the beginning. This conclusion was given further support by an interview with an R&D manager of a high-tech SME who indicated that technology and patent mapping was used only in interaction case of alliance partners with close cognitive distance. In cases of a low level of knowledge resources exchange the higher level of technology mapping can instead therefore be seen as a communication tool. The positive link between knowledge resources exchange and task division suggests that there is a need to exchange knowledge first in order to determine an innovation locus based on the core competencies and facilities of the companies. However, no significant positive link was found from technology mapping to task division, which underlines the finding that the potential of technology mapping as an alliance communication tool is often not exploited to full extent. When it comes to alliance performance, the direct link from knowledge resources exchange to exploration performance stands in contrast to exploitation performance, where knowledge resources exchange—via task division—leads to alliance synergy, or—via technology mapping—to exploitation performance.

3.5 Discussion and conclusions

The objective of the present study was to explore the attributes of alliances in the biotech industry in order to derive recommendations for how to improve policy support for SMEs in the open innovation process. It was hypothesized that innovation alliances that show a higher level of complementarity (due to cognitive distance) and deal with cognitive distance by intensive knowledge resources exchange would show greater synergy creation, and ultimately a higher level of innovation performance. Our empirical findings in the Dutch biotech sector support this hypothesis. Our research also supports earlier findings that alliances allow for access to complementary resources (Ireland and Hitt, 1999) and that alliance companies often get close enough to each other in order to acquire tacit knowledge (Lane and Lubatkin, 1998). Furthermore it was shown that, depending on the alliance potential, a differentiated alliance execution process employing different governance mechanisms is required to achieve synergy and, in the end, a higher level of exploration and/or exploitation performance. As hypothesized, both explicit and tacit knowledge resources exchange were demonstrated to be of central importance in the alliance execution phase. The level of knowledge exchange also determined which governance mechanisms were selected for the alliance. Knowledge resources exchange has to be based on the exchange of human resources and an open information flow in order to allow the exchange and conversion of tacit knowledge. It is therefore concluded that mechanisms to enhance knowledge resources exchange, such as human resources exchange, deserve special attention in innovation alliances.

The level of knowledge resources exchange was found to suffer from a lack of clarity about the division of the alliance outcomes among the partners. This indicates that, first of all, it is of crucial importance to make good contractual arrangements prior to alliance execution (Tepic, 2012). A collaboration support tool, such as technology mapping, can then be used to create a common view on IP division among the partners and prevent the problem described by Shan (1990), i.e., both parties claiming ownership of the generated alliance output. Up front clarity about future IP division is also of crucial importance in order to secure investors. Shan and Song (1997) found that the



→ Path significant at alpha = 0.05 level
➡ Path significant at alpha = 0.01 level

-* negative path coefficient

Figure 3.2. Significant paths in the PLS model of innovation alliances

number of patents acquired was one of the principal triggers for obtaining foreign equity investors.
In the agricultural biotechnology sector there are fewer alliances and partnerships relative to the health biotech sector (see Bagchi-Sen et al., 2011). Bagchi-Sen et al. (2011) have explained this finding on the basis of the structure of the agrifood biotech industry, in which few big companies state a permanent threat of take-over that prevents smaller biotech firms from entering into alliances with them; as one of the CEOs of an agricultural biotech SME in our sample stated, she would rather *cooperate with other small companies, research institutes and universities, or with a client, but not with the big competitors next door.* Such a situation calls for a further stimulation of the open innovation process itself, by creating the trust necessary to enter into cooperations by providing clarity on the IP situation not only when entering the alliance but also during the alliance process itself.

Chapter 4

Management of innovation alliances[5]

4.1 Introduction

To remain competitive in a world of global competition implies that a company has to adapt to changing situations at an increasing speed. Product life cycles are shortening and require companies to innovate in ever shorter time intervals. *The pressure to do more with less inexorably pushes […] companies to focus on their unique, hard to imitate and distinctive core competencies, continually nurturing and enhancing them, while abandoning those activities in which they do not possess distinctive competencies* (Omta and Van Rossum, 1999, see also Hamel and Heene, 1994, Hamel, 1996, Sanchez et al., 1996). At one point in time, the innovation potential of a single company, based on its resources and core competencies, might be enough to face the competition. However, if transformation of the company's resources and capabilities is needed to face the fast changing business competition this might take too much time, and the new capabilities could be outdated already at the moment the change is achieved. Under such fast changing circumstances a company might win the race by engaging in an innovation alliance, combining its own resources and capabilities with those of partnering organizations. Therefore *the capability of building and maintaining inter-organizational network relationships, such as joint ventures, license agreements, supplier customer partnerships and strategic alliances is increasingly viewed as key to sustained competitive advantage* (Omta and Van Rossum, 1999). Also several empirical studies suggest that 'open' innovation (Chesbrough et al. 2008), cooperating with other organizations in the innovation process, provides a greater innovation potential compared to closed (in-house) innovation (Christensen et al., 2005, Fetterhoff and Voelkel, 2006, Dittrich and Duysters, 2007, Batterink, 2009).

But there is also a downside to the new interconnectivity of firms. Companies are fearing that they are becoming increasingly vulnerable, due to a too large dependency on external innovation sources (Millson et al., 1996, Jonash, 1996), while connecting to one or a limited number of alliance partner(s) may exclude the access to others. Critical issues that play a role in a strategic alliance range from: Which company is contributing what, how high are the coordination costs, is the exchange of knowledge symmetric enough (problem of outlearning the partner, Hamel, 1991); and which company is benefiting most from the results (Farr and Fischer, 1992). The conclusion may be that open innovation is not a self-evident choice. Instead the decision boils down to the managerial question: *Is there a balance between the potential benefits of open innovation and the potential risks and the additional coordination costs?* To achieve this balance, different governance

[5] This chapter is based on Garbade, P.J.P., S.W.F. Omta and F.T.J.M. Fortuin, The interplay of structural and relational governance in innovation alliances, submitted for publication to *R&D Management*

mechanisms can be used. In contrast to the possibility of the occurrence of inter-organizational collaboration problems, not many studies are directed at the governance mechanisms to control for them. And especially the necessary interplay between the structural and relational governance mechanisms is far less investigated.

The present chapter aims to extend the discussion in the governance literature whether structural and relational governance mechanisms complement or substitute each other in innovation alliances. Structural governance mechanisms refer to formal agreements that are often written down in contracts (Zenger et al., 2002), in the present chapter conceptualized as the division of tasks within the alliance and to upfront contractual and non-contractual input, output and risk related agreements. Relational governance mechanisms are based on trust, using informal norms and rules indicating how decision rights, ownership rights and rewards are distributed among the alliance partners. In innovation literature much attention has been spend on relational governance, which is expected to offer more flexibility needed for innovation than the as rigid perceived regulations in structural governance. Therefore, relational governance is perceived to substitute rather than complement structural governance in innovation literature (Dyer and Singh, 1998, Gulati, 1995, Larson, 1992, Adler, 2001). However, following Poppo and Zenger (2002) and Tepic et al. (2011), this assumption is challenged and it is argued that structural and relational governance complement rather than substitute each other. It is argued therefore that the role of structural governance providing a solid basis for creating trust, especially in alliances in which the partners do not know each other, is clearly underexposed. To fill up this gap, a model conceptualizing the innovation alliance from inception to performance was tested using Partial Least Squares, employing a cross-sectional dataset of 94 innovation alliances in the Netherlands, Belgium, Germany and Austria.

The remainder of this chapter is organized as follows: Section 4.2 introduces the theoretical framework. Based on the resource based view (RBV), the knowledge based view (KBV) and the knowledge governance perspective the conceptual model is build, in which the different concepts are included structured to the phase in the alliance process, the alliance potential, formalization, execution phase and performance phase. In Section 4.3, the operationalization of the constructs and the methods of data collection and data analysis are presented. Section 4.4 starts with the baseline description of the participating companies and their alliances. The data are further analyzed using partial least squares modeling, comparing the theoretically expected model with the empirically found model. In Section 4.5 the main conclusions are drawn.

4.2 Theoretical framework

The theoretical framework of this chapter builds on the resource/knowledge based view and the knowledge governance perspective, which have been introduced in Section 1.3.2 – 1.3.3. Whereas the structural governance perspective builds on detailed contracts and agreements (Poppo and Zenger, 2002), relational governance tries to substitute these structural elements by social norms, reinforced by social interaction (Zenger et al., 2002, Dekker, 2004, Grandori and Furlotti, 2010). Structural agreements can be made upfront an alliance, while relational trust has to grow during the alliance execution in case there was no previous experience with the alliance partner(s). Therefore, structural agreements can be expected to be made already during the formalization phase of the alliance, while relational trust is positioned in the alliance execution phase.

4.2.1 Conceptual Model

Since the 1980s strategic alliances are increasingly used by organizations to innovate (De Man and Duysters, 2005). Especially in the ‘open’ innovation literature (Chesbrough et al., 2008), strategic alliances are advocated as important vehicles to get access to external resources and knowledge in order to innovate more cost and time efficient. Gulati (1998) defines a strategic alliance, *as voluntary arrangements between firms involving exchange, sharing, or co-development of products,* *technologies or services*. De Man and Duysters (2005) define it as *cooperative agreements in which two or more separate organizations team up in order to share reciprocal inputs while maintaining their own corporate identities.* And Hamel (1991) emphasizes that in an alliance *access to people, facilities, documents, and other forms of knowledge is traded between partners in an on-going process of collaborative exchange*. Sourcing from these three definitions, for this study an innovation alliance is defined as a cooperative agreement between two or more parties with the aim to innovate, based on an ongoing collaborative exchange, in order to develop new knowledge, products and processes, while maintaining their corporate identity.

Based on the structural and relational perspective several factors that are expected to play a role in an innovation alliance and their assumed relationships are presented in the conceptual model in Figure 1. In this model, the resource based view (RBV), that regards the formation of an innovation alliance as an attempt to build a unique set of resources that provide competitive advantage to the partners (Dyer and Singh, 1998) is used to conceptualize the alliance potential, while the knowledge based view (KBV) as an extension of the RBV will be used to assess the knowledge exchange aspect. Whereas the interdependency theory is used to discuss the possible consequences of a high degree of interdependency in strategic alliances (Lazzarini et al. 2001). Building on these theories, the conceptual model shows the different constructs, according to their impact on the different phases in the alliance collaboration process, the alliance potential, formalization, execution and performance phase.

4.2.2 Alliance potential

<u>*Alliance importance*</u>
As discussed in Section 3.2.2, the intentions and motivation to turn an alliance into a success are expected to play an important role in alliance performance. The more partners expect to benefit from the alliance, the more they are likely to invest in it. This factor is termed ‘alliance importance’. The importance status of an alliance refers to the strategic importance of an alliance for a company to achieve its goals. An alliance is consequently ranked in terms of priority compared to the other alliances in which the company is engaged, as well as compared to the other activities of the company. Since it is assumed that scarce company resources are allocated according to the highest expected returns, the amount and value of resources dedicated to an alliance should reflect its assumed importance for the company. In Table 4.1 the alliance importance is therefore indicated by the number of company staff taking part in the alliance collaboration.

<u>*Resource complementarity*</u>
As discussed in Section 3.2.2, resources have to be different in order to be complementary. This implicates that partners work in different research areas, use different technologies and possess different expertise. In turn this requires the ability to understand each other’s knowledge contribution. Cohen and Levinthal (1990), point at the importance of absorptive capacity; defined as a company’s capability to recognize the value of new information, its ability to assimilate it and to apply it to commercial ends. Absorptive capacity in an alliance is dependent on pre-alliance knowledge overlap (Mowery et al., 1996, Dyer and Singh, 1998) and further assumed to be influenced by interaction routines between the partners (Dyer and Singh, 1998). Taking into account the value of newness and the absorptive capacity needed to catch it, there is then an optimal level of complementarity to be expected (Schoenmakers and Duysters, 2006, Nooteboom et al., 2007). So a higher level of complementarity is a necessary but not a sufficient condition to achieve a higher alliance performance.

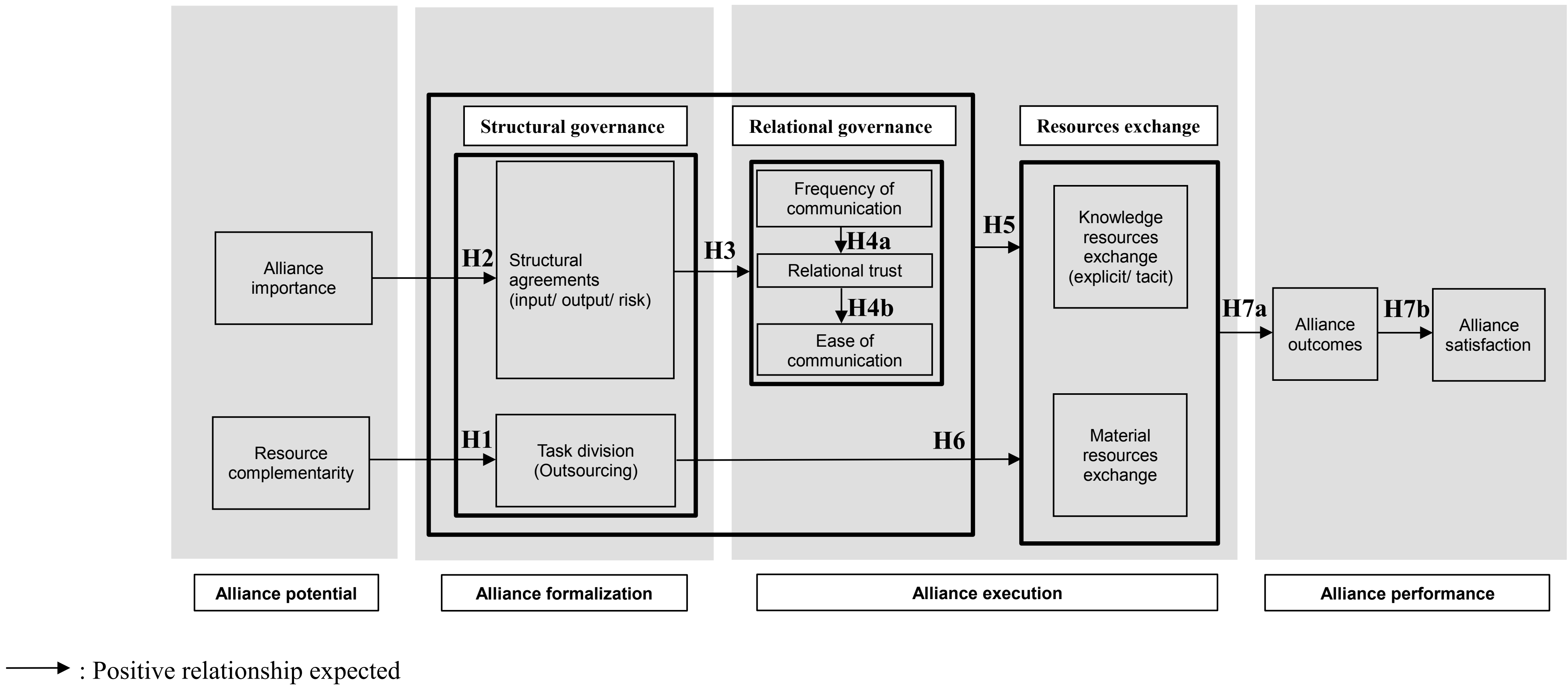


Figure 4.1. Conceptual model

4.2.3 Alliance formalization

After the alliance partner has been selected, the conditions of the partnership have to be negotiated in order to execute the alliance collaboration and to exchange knowledge (Easterby-Smith et al., 2008). During the alliance formalization stage it is determined how to execute the alliance, rather as a formal or informal partnership and decided upon the interdependence level of the partnership.

Task division

Thompson (1967) distinguishes three types of interdependence: pooled, sequential and reciprocal. He indicates that pooled interdependence constitutes the lowest level of interdependence, then comes sequential interdependence, while reciprocal interdependence is placed at the highest level of interdependence between partners. Lazzarini et al. (2001) refer to strategic alliances as an example of reciprocal interdependence, so in the present chapter innovation alliances are regarded to have a high interdependency level. In interdependence literature also a distinction is made between task, goal and reward interdependence (van Vijfeijken et al., 2002, Wageman and Baker, 1997). While Sambasivan et al., (2011) found a positive relationship in an alliance between level of interdependence and trust, commitment and communication, at least for task interdependence also negative effects have been reported due to the increased contingencies that have to be managed (Victor and Blackburn, 1987). Higher task uncertainty in an innovation alliance makes that impersonal coordination mechanisms frequently fail (Van de Ven et al., 1976), while also the coordination costs might increase with higher task interdependence, due to a higher number of interaction moments needed. A lower level of task division in an innovation alliance might therefore imply that too much of a company's resources (specifically the staff working hours) have to be spent on coordinating the activities between partners. Consequently, an optimal level of task interdependency can be expected to develop a new product or process at a reasonable speed and efficiency. In cases of (too) high task interdependence it should be tried to reduce the level of interdependence by dividing more tasks. Since innovation alliances can be assumed to show a high level of complementarity to make optimal use of a company's core competences and to save its scarce resources (Batterink, 2009), it can be expected that companies are that able to divide the tasks in such a way to lower the level of task interdependence will have increased the alliance potential. So it can be hypothesised:

Hypothesis 1: In a successful innovation alliance a larger complementarity of material and immaterial resources will be positively related to a higher level of task division.

Structural agreements

There are two dimensions that determine the power of structural agreements. Firstly, to what extent and into which detail were structural aspects of the alliance discussed among the partners and agreed upon (non-contractual agreements). Secondly, to what extent are they included in a formal alliance contract (contractual agreements), that could be used in a court case (Grandori and Furlotti, 2010) to decide who owes what to whom or in case of results who is the owner of the results. This corresponds to what Tepic et al. (2011) define as the formalization level of an alliance, which they conclude is necessary to stabilize a heterogeneous innovation network. Also non-contractual (or extra-contractual) *agreements can be used to clarify the interest based incentives, bringing rational commitment and structure to the collaboration* (Tepic, 2012, Tepic et al., 2011). *At the same time they allow for flexible adjustments (Tepic et al., 2011).*

Gulati (2007) provides a categorization of structural agreements which is reduced to input, output and risk related agreements in the present chapter. When entering an alliance it has to be clarified what to invest in the alliance, what to expect in terms of outcomes and which risks should be covered. Input agreements may structure working hours' contributions, who is supposed to tackle which tasks, but also who pays for what. Output agreements may include the deliverables and future IP that is expected as a result of the alliance (see e.g. Omta and Van Rossum, 1999, Chiesa and Manzini, 1998). Last but not least, there is also the chance of alliance collaboration problems because of unforeseen reasons. This could be conflicts among the cooperating partners, but also based on external factors, such as the bankruptcy of a partner that could cause the termination of the alliance. These eventualities can be covered by risk related agreements. As the alliance importance to the company increases, dependent in how far an alliance is expected to impact the overall company's performance, the importance to minimize alliance related risks, by investing in good structural agreements to safeguard the alliance execution, increases as well. Therefore it is hypothesized.

Hypothesis 2: A higher importance status given to the alliance will be positively related to a higher level of structural agreements.

4.2.4 Alliance execution

During the alliance execution phase, material and (explicit and tacit) knowledge resources have to be exchanged among the partners to develop new products and processes. In the present chapter the following relational governance elements were identified as essential to facilitate the resource exchange: relational trust and communication (frequency and ease).

<u>*Relational trust and communication*</u>

Relational governance is based on repeated interaction (Dekker, 2004, Poppo and Zenger, 2002, Granovetter, 1985). A key concept in the relational view of governance is trust (Tepic et al., 2011). Relational trust includes positive expectations toward the trustee's intentions. (Rousseau et al., 1998, Ring and Van de Ven, 1992). It builds on past experience with an alliance partner or if no past experience exists, builds on the experience with the partner that builds up during the alliance execution phase. Relational trust is therefore operationalized in the present chapter by the extent to which the alliance partner did what he promised, the extent to which opportunistic behavior occurred during the alliance collaboration and in how far misalignments of the various contributions were a problem.

The commitment to an alliance is positively related to the learning intent of the partner firms (Wu and Cavusgil, 2006), what in turn is expected to be positively related to the communication frequency among the alliance partners in terms of face-to-face, telephone and e-mail contact. A higher communication frequency is assumed to build relational trust and preserves it by providing clarification possibilities in cases of misunderstanding. *To communicate frequently, sending all relevant memo's and team reports helps in creating a climate of trust* (Omta and Van Rossum, 1999). However, whether a higher communication frequency will lead to a higher level of inter-organizational learning will depend on the ease of communication, whether it is easy to get in contact with the persons that possess the targeted knowledge. If there is a high risk perception concerning the leaking of confidential information, a high communication frequency does not necessarily lead to the exchange of key information, since people will hold back, what they fear to loose. Clear upfront contractual and non-contractual agreements can provide assurance to each alliance partners that the other(s) will not act opportunistically. In line with this reasoning, Tepic et al. (2010) found no transition from structural to relational governance mechanisms in less successful projects. So it is hypothesized:

Hypothesis 3: In a successful innovation alliance structural (contractual and non-contractual) agreements are needed to provide an assurance platform on which relational governance mechanisms can strive.

Hypothesis 4: In a successful innovation alliance the frequency of communication will be positively related to relational trust (4a), while the increasing relational trust will lead to ease the communication among the alliance partners (4b).

Knowledge resources exchange (explicit and tacit)
The knowledge resource exchange has been extensively discussed in Chapter 3 under Section 3.2.3. The operationalization of knowledge exchange in the present chapter builds on the level of information exchange between the partners, as a measure of the explicit knowledge exchange, and on the level of human resource exchange, as a proxy for the tacit knowledge exchange. Faems et al. (2007) show in their case study that governance mechanisms can indeed initiate knowledge exchange. Going a step further it is suggested that it is especially the structural governance mechanisms that provide the platform for relational governance in innovation alliances, and that the combination makes optimal knowledge exchange in an innovation alliance possible. This leads to the following hypothesis:

Hypothesis 5: In a successful innovation alliance the combination of structural and relational governance mechanisms will be positively related to knowledge resources exchange.

Material resources exchange
While the level of communication in an alliance provides the necessary flow of knowledge there can also be a need to exchange material resources to innovate time and cost efficient. This might include the exchange of specific laboratory equipment and/or technological tools that one of the partners provides to the other partner(s) in the alliance. This might apply even more in case there is a high complementarity not only in terms of knowledge but also in terms of equipment and tools. Following the idea underlying task division in an alliance, to make best use of the scarce resources, material resources should be exchanged, or at least shared. Within an alliance, expensive tools and equipment that an alliance partner can provide should not be purchased. Depending on the complexity to use these tools and equipment by the alliance partner(s), there might also be a need of knowledge resources exchange. If this is related back to the level of task division in an alliance to make most efficient use of company's resources, it can be hypothesized:

Hypothesis 6: A higher level of task division will allow enhanced resources exchange in the alliance collaboration process.

4.2.5 Alliance performance
Performance can be assessed at the innovation process level (innovative performance) and at the industrial outcome level (industrial performance,(Omta and De Leeuw, 1997). Since the present study focuses on innovation alliances, it is looked at performance at the alliance level. Alliance performance in the present chapter therefore focuses on the output resulting from the collaboration. The output focus lies on in how far the alliance resulted in new products and processes (alliance outcomes) and takes into account the satisfaction of the alliance partners.

Alliance outcomes and satisfaction
Hamel (1991) distinguishes between value creation and value appropriation in an alliance. The alliance outcomes represent the value created due to the alliance. In the present chapter, alliance outcomes are measured by the extent to which there were new products, processes and knowledge developed due to the alliance. The value appropriation (Hamel, 1991) within an alliance is difficult to measure directly. It is assumed that in cases where the value appropriation failed or were the alliance value created was not distributed according to the alliance contributions of the partners, a lower level of alliance satisfaction can be expected. Therefore, alliance satisfaction was used as a proxy to measure value appropriation within an alliance. Alliance satisfaction is operationalized by

measuring to what extent the partners' objectives were achieved and by the willingness to cooperate again with the same partner(s). Knowledge and material resources have to be exchanged among the partners to create and appropriate value within an innovation alliance. Therefore it is hypothesized:

Hypothesis 7: The level of (knowledge and material) resources exchange will be positively related to alliance outcomes (7a), whereas alliances outcomes will be positively related to alliance satisfaction (7b).

4.3 Methods

The detailed items used to measure each construct are listed in Table 4.1.

Table 4.1. Operationalization of constructs

Constructs		**AVE Average Variance Extracted**	**Composite Reliability**	**R^2**	**Cross Loadings**	**Indicator Questions** operationalized using 7-point Likert scales from 1 (not at all) to 7 (to a very large extent) unless indicated differently behind the question
Alliance importance		1	1	–*	1	*Number of staff of your company involved in the alliance*
Resource complementarity		0.59	0.85	–*	0.85	*To what extent worked the most important partner in this alliance on a different research area than your company?*
					0.81	*To what extent possessed the most important partner in this alliance a different expertise than your company?*
					0.78	*To what extent used the most important partner in this alliance a different technology than your company?*
					0.61	*To what extent were there differences in equipment, technology, and knowledge that were complementary?*
Task division		0.68	0.81	0.21	0.88	*Activities were outsourced to the alliance partner because: limitations of the technical equipment of our company.*
					0.77	*Activities were outsourced to the alliance partner because: limitations of the technical competences or our company.*
Structural governance						
Structural agreements	***Input related agreements***	0.61	0.82	–	0.83	*To what extent were agreements made about division of tasks at the beginning of the alliance?*
					0.77	*To what extent were agreements made about distribution of financial input at the beginning of the alliance?*
					0.74	*To what extent were agreements made about distribution of input from staff at the beginning of the alliance?*
	Output related agreements	0.62	0.83	–	0.89	*To what extent were agreements made about deliverables per 'go - no go' moments at the beginning of the alliance?*
					0.76	*To what extent were agreements made about property rights of revenues/results at the beginning of the alliance?*
					0.69	*To what extent were agreements made about confidentiality at the beginning of the alliance?*
	Risk related agreements	0.83	0.91	0.07	0.94	*To what extent were agreements made about procedures for resolution of conflicts at the beginning of the alliance?*
					0.89	*To what extent were agreements made about early termination of the cooperation at the beginning of the alliance?*

Relational governance						
Relational trust		0.57	0.80	_	0.84	*The most important partner did always what he promised.*
					0.78	*In the alliance opportunism was not a problem.*
					0.63	*In this alliance the alignment of the various contributions was not a problem.*
Communication	***Frequency of communication***	0.64	0.84	0.07	0.92	*How often did you have telephone contact with the most important partner? 1 = once per year or less, 2 = once every 6 month, 3 = once per quarter, 4 = monthly, 5 = once every two weeks, 6 = weekly, 7 = more than once per week*
					0.90	*How often did you have e-mail contact with the most important partner? 1 = once per year or less, 2 = once every 6 month, 3 = once per quarter, 4 = monthly, 5 = once every two weeks, 6 = weekly, 7 = more than once per week*
					0.51	*How often did you have face-to-face contact with the most important partner? 1 = once per year or less, 2 = once every 6 month, 3 = once per quarter, 4 = monthly, 5 = once every two weeks, 6 = weekly, 7 = more than once per week*
	Ease of communication	0.55	0.71	0.19	0.85	*It was very simple to speak with everyone you need, regardless of rank or position.*
					0.62	*The risk of leaking out confidential information was... (1=very large to 7= very small)*
Resources exchange						
Material resources exchange		1	1	0.21	1	*The most important partner supported us by delivery of equipment and tools.*
Knowledge resources exchange	***Explicit knowledge exchange***	0.86	0.93	0.50	0.96	*The most important partner gave us the information where we asked for.*
					0.90	*We gave our most important partner the information he asked for.*
	Tacit knowledge exchange	0.68	0.81	0.11	0.92	*Exchange of human resources was important in this alliance.*
					0.73	*Was there exchange of employees to work in each other's company?*
Alliance Performance						
Alliance outcomes		0.60	0.86	0.44	0.83	*This alliance resulted in synergy.*
					0.79	*This alliance has developed new knowledge.*
					0.76	*This alliance has developed new products.*
					0.72	*This alliance has developed new processes.*
Alliance satisfaction		0.82	0.90	0.69	0.92	*In a new project I prefer to work again with the most important partner.*
					0.89	*According to my opinion, the goals we had in mind with this alliance were reached.*

* - for the independent constructs, with no predicting constructs, no R-square can be calculated

For the present study a sample was composed of SMEs and large firms and a number of knowledge institutions mostly active in the green and pharma biotech sectors (Section 4.4.1 for an overview of the companies). To collect the data, an online questionnaire was used, which was pretested in two stages before launching it to the selected companies. A first pretest was done in 13 companies and one knowledge institution using face-to-face interviews to learn if the questions were understood correctly. A second pretest of the online questionnaire was done in 4 companies. The respondents filled in the online questionnaire, and then participated in a follow up face-to-face interview a few days later to discuss their answers. After the two pretests confirmed the reliability of the questionnaire, the firms were contacted by e-mail, containing a link to the online questionnaire. Eighty-eight firms filled in the questionnaire, of which 77 could be selected to participate in this study. They reported about 94 alliances.

Partial least squares, which has been introduced in Section 3.3 has also been used for the empirical testing of the conceptual model in Chapter 4. Before testing the conceptual model with PLS the dataset was analyzed for possible differences between respondent groups, employing the Man Whitney U Test. In the baseline description a number of significant differences (asymptotically, two-tailed, alpha=0.05) are discussed.

4.4 Results

4.4.1 Baseline description

In total, 77 respondents from companies and knowledge institutions provided answers on 94 innovation alliances; 17 respondents provided information about two alliances in which their company or knowledge institution was involved, and one respondent about three alliances of his organization. Information about 59 alliances was gathered from 49 respondents located in companies and knowledge institutions in the Netherlands; 25 alliances by 20 respondents of companies and knowledge institutions in Germany; 5 alliances by four respondents in Switzerland; 4 alliances by three respondents in Austria and one alliance by one respondent in Belgium. Information about 38 alliances was provided by respondents from green biotech companies, such as plant breeding, breeding support, crop protection companies; 14 alliances by respondents from pharma biotech companies, 28 by food (processing) companies and 14 by respondents from other high-tech sectors such as nano-electronics and embedded systems. In 64 alliances the respondent came from a SME, 21 alliance questionnaires were answered by large companies and in nine cases the respondents came from a knowledge institution.

In more than 50% of the cases more than 2 companies were involved in the alliance. Knowledge institutions were mentioned as most important alliance partner in 24% of the cases. These alliances were characterized by the fact that on average more organizations were involved (6.2 on average), compared to 3 organizations in alliances where a company was the most important alliance partner. About half of the alliances are located in different clusters or cluster like set-ups, such as incubator centers, university campuses or business parks (Table 2). Most of the alliances had a long history, thirty-five percent were older than 5 years and nearly half of the alliances (46%) were between 3 and 5 years old. Only sixteen percent of the alliances were younger than 3 years.

Table 4.2. Demographics of Organizations (n=77) and their alliances (n=94)

		Organization	Alliances
	Bioscience parks, university campuses*	19	**25**
	Clusters**	15	**21**
	Not located in bioscience parks or related to clusters	43	**48**
Total		77	**94**

* Leiden Bioscience Park, Utrecht Science Park, Amsterdam Science Park, Maastricht Biopartner Center, Eindhoven TU ,Agro business Park Wageningen, Biopartner Center Wageningen, NXP Noviotech Campus Nijmegen, Biopark Regensburg, BioPharmPark Dessau, BioTechnikum Greifswald, Frankfurt Biotechnology Innovation Center (FIZ), Universitaetsklinikum Magdeburg, Zenit Technology Park Magdeburg, Ghent University campus
**Food Valley NL, Health Valley, Seed Valley, Amsterdam BioMed Cluster, Cluster Ernährung, Munich Biotech Cluster, BMD Life Sciences Agentur Sachsen Anhalt Cluster, BioCon Valley Mecklenburg-Vorpommern

Companies located in clusters reported the highest frequency of telephone contacts with their most important alliance partner, while respondents of companies located in a bioscience parks or university campuses indicated that it was easy to talk to anyone regardless of rank and position within their alliance. Also in alliances with knowledge institutions as most important alliance partner it was stated that it was easy to talk to anyone in the partner organization, regardless of rank and position.

Respondents of SMEs reported on average a higher resource complementarity than the respondents of the large companies. This could be explained by the fact that SMEs cover a smaller material and knowledge resource field than big companies that are assumed to have rather a large spread of expertise due to the number and diversity of employees. The SMEs also indicated a lower level of upfront agreements but a higher level of synergy achieved per alliance. In addition, it is worth mentioning that in the perception of the SME respondents the results of the alliances are on average slightly (at a one tailed level) better than the ones reported by respondents of the large companies concerning all performance measures.

Upfront agreements about property rights and revenues were made to the largest extent in the alliances of the green biotech companies. In the alliances of the pharma biotech companies the opportunism level was lowest, it was easiest to talk to anyone and the willingness to collaborate in a new project was the highest.

4.4.2 Measurement model

The model specifications are adapted from the model specifications described in Chapter 3 under Section 3.4.2 and 3.4.3.

Table 4.3. Construct correlations

		1	2	3	4	5	6	7	8	9	10	11	12	13	$\sqrt{AVE}$
1	Alliance importance	1													1.00
2	Resource complementarity	-.16	1												0.78
3	Task division	.24*	.38**	1											0.93
4	Input related agreements	.01	.16	.17	1										0.91
5	Output related agreements	.13	.12	-.01	.53**	1									0.80
6	Risk related agreements	.27**	.11	-.21*	.32**	.44**	1								0.74
7	Relational trust	-.18	.16	.09	.09	.01	-.05	1							0.79
8	Frequency of communication	.02	.13	-.07	-.02	-.27**	-.02	.10	1						0.83
9	Ease of communication	-.31**	-.04	.04	.07	-.12	-.19	.44**	.12	1					0.75
10	Material resources exchange	-.01	.30**	.44**	-.04	-.05	-.13	-.08	.19	-.17	1				0.77
11	Explicit knowledge exchange	-.33**	.11	.19	.27**	.04	-.06	.63**	.18	.43**	-.06	1			1.00
12	Tacit knowledge exchange	-.02	.17	.25*	-.05	-.11	-.05	.11	.19	.01	.46**	.21*	1		0.78
13	Alliance outcomes	.02	.29**	.25*	.11	-.03	.00	.52**	.22*	.20	.24*	.49**	.42**	1	0.83
14	Alliance satisfaction	-.05	.16	.07	-.06	-.14	-.03	.71**	.24*	.34**	.03	.55**	.32**	.73**	0.91
	$\sqrt{AVE}$	1.00	0.78	0.93	0.91	0.80	0.74	0.79	0.83	0.75	0.77	1.00	0.78	0.83	

* Correlation (Pearson) significant at alpha = 0.05 level (two tailed)
** Correlation (Pearson) significant at alpha = 0.01 level (two tailed)

Individual item reliability

To measure individual item reliability, the cross-loadings between the indicators and the constructs were checked. Every indicator should have a cross loading higher than 0.4 , while higher than 0.7 is desirable, and indicators to which the constructs are not connected should not show higher cross-loadings than those to which they are connected (Hulland, 1999). The cross-loadings of the indicators in the present study fulfill these requirements (Table 4.1).

Convergent validity
The composite reliability (Section 3.4.3) was used to measure the convergent validity of the constructs. All composite reliability scores were above 0.7 (Table 4.1).

Discriminant validity
The discriminant validity has been assessed by using the AVE (i.e., the average variance shared between a construct and its measures). The square root of the AVE should be higher than the construct correlations. Further all AVEs should be above 0.5. Table 4.3 shows that both requirements are met.

4.4.3 Structural model

For this model, bootstrapping (see Section 3.3) shows that all path coefficients are significant at least at $\alpha = 0.05$ level and one path coefficient at a 0.06 level (one tailed). The significance of estimated coefficients in the structural model can be seen in the t-values of Table 4.4. The extent to which the endogenous constructs are explained by the exogenous constructs in the model can be determined on the basis of the R^2 values (Table 4.1), wherein R^2 values of 0.67, 0.33, and 0.19 (with regard to PLS path models) are seen as substantial, moderate, and weak, respectively (Chin, 1998). Figure 4.2 provides an overview of the PLS model based on the path coefficients provided in Table 4.4. The PLS model has been checked for common method bias following Podsakoff et al. (2003) by applying Harman's single-factor test (1976) using principal axis factoring (Harman, 1976). Common method variance was not a problem since items loaded on multiple factors and one factor did not account for most of the covariance.

Table 4.4. Significance of the estimated coefficients in the structural model

	Path coefficient	T Statistics
Alliance importance -> Risk related agreements	0.27	2.69**
Resource complementarity -> Task division	0.41	4.97***
Resource complementarity -> Material resources exchange	0.16	1.69*
Risk related agreements -> Task division	-0.26	2.63**
Task division ->Tacit knowledge exchange	0.27	2.51**
Task division -> Material resources exchange	0.38	4.12***
Input related agreements -> Explicit knowledge exchange	0.22	2.82**
Output related agreements -> Frequency of communication	-0.27	2.53**
Frequency of communication Tacit knowledge exchange	0.21	1.59
Relational trust -> Ease of communication	0.44	4.82***
Ease of communication -> Explicit knowledge exchange	0.19	2.21*
Relational trust -> Explicit knowledge transfer	0.51	5.96***
Relational trust -> Alliance outcomes	0.37	3.66***
Explicit knowledge transfer -> Alliance outcomes	0.21	2.07*
Tacit knowledge exchange -> Explicit knowledge exchange	0.17	2.24*
Tacit knowledge exchange -> Alliance outcomes	0.25	2.72**
Material resources exchange -> Alliance outcomes	0.17	1.81*
Relational trust -> Alliance satisfaction	0.46	6.96***
Alliance outcomes -> Alliance satisfaction	0.49	6.70***

*= significant with a likelihood of mistake ≤ 5 percent one tailed
**= significant with a likelihood of mistake ≤ 1 percent one tailed
***= significant with a likelihood of mistake ≤ 0.1 percent one tailed
The path coefficients are one tailed because the expected directions are indicated by the hypotheses.

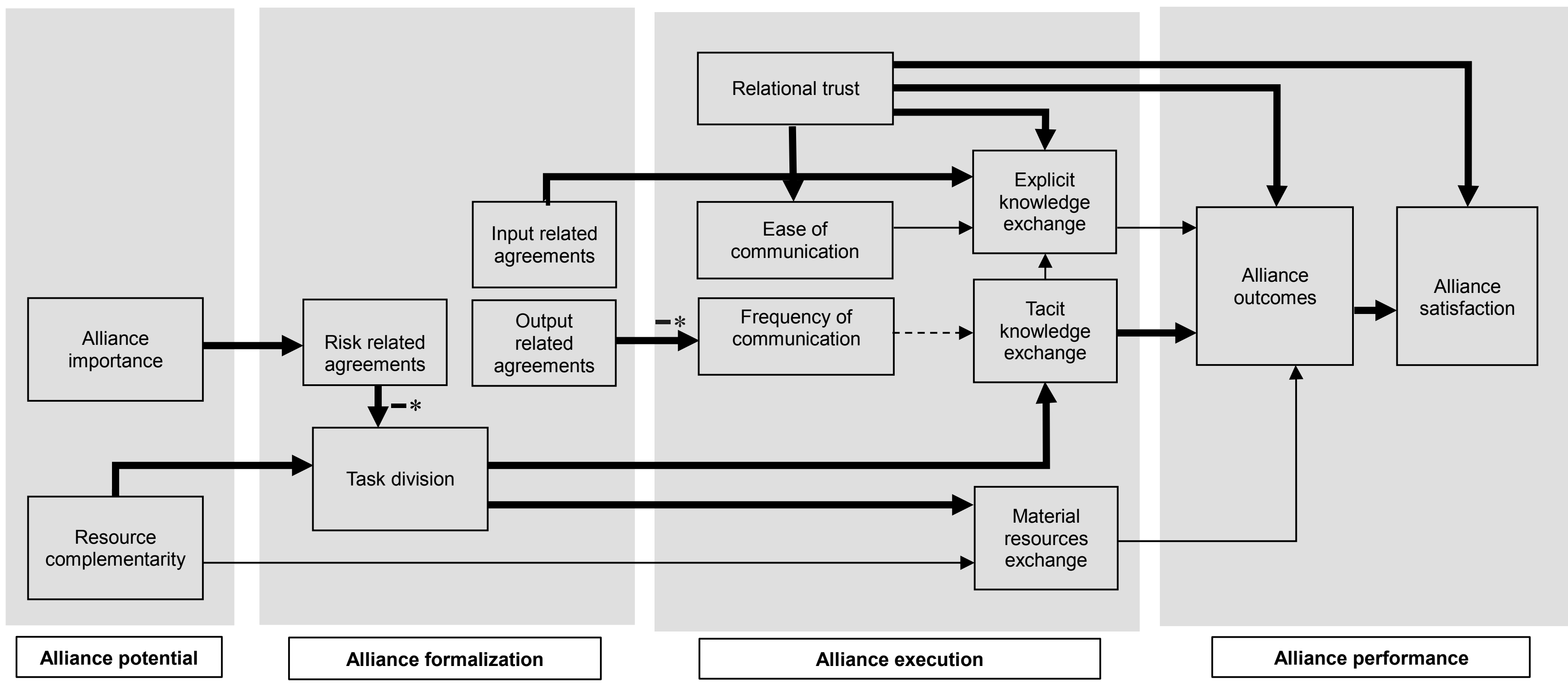
4.4.4 Construct relations and hypotheses testing

Table 4.4 and Figure 4.2 show that the alliance importance is positively related to risk related agreements, partly confirming Hypothesis 2. Resource complementarity is positively related to the level of task division within the alliance, which confirms Hypothesis 1. Resource complementarity is also positively related to material resources exchange. There is further a positive relation between the level of task division and the material resources exchange. The knowledge resources exchange splits into two constructs, the explicit and the tacit knowledge exchange. The level of task division positively relates to tacit knowledge exchange, whereas tacit knowledge exchange is positively related to explicit knowledge exchange.

Material resources exchange, explicit and tacit knowledge exchange and relational trust all show a direct and positive relationship with alliance performance in terms of alliance outcomes, which confirms Hypothesis 6 and 7a, while alliance outcomes and the relational trust in an alliance are directly and positively related to alliance satisfaction, confirming Hypothesis 7b.

The structural input related agreements positively relate to explicit knowledge exchange. Also relational trust positively relates to explicit knowledge exchange, confirming Hypothesis 5. Communication is represented by two constructs: frequency and ease of communication. Relational trust positively relates to ease of communication, whereas the ease of communication in turn positively relates to explicit knowledge exchange, leading to higher alliance performance, confirming Hypothesis 4b. No direct relation between the frequency of communication and relational trust was found, which leaves Hypothesis 4a not confirmed. The mediating effect of ease of communication on the positive relationship between relational trust and explicit knowledge exchange follows our argumentation in the theoretical framework. A better relational trust creates an ease of communication among the partners (and vice versa) leading to a higher level of (explicit) knowledge exchange.

There are two negative relationships found in the empirical model connected to the structural governance constructs output and risk related agreements. The output related agreements negatively relate to the frequency of communication. If it is assumed that the frequency of communication results on the one hand from the learning intent of the alliance partners, but on the other hand also from alliance coordination related communication, than it can be argued that a higher level of output related agreements lessens the need to renegotiate during the alliance execution phase, which reduces the communication frequency. Or stated differently, if the communication channels are not exhausted by coordination related communication, then there is more capacity to exchange learning related content. The positive effect of communication frequency on tacit knowledge exchange stands in line with this argumentation. Therefore the negative relationship found between the output related agreements and the frequency of communication is considered as an approval of the hypothesized positive impact of structural governance mechanisms in terms of easing coordination during the alliance execution phase. The second negative relationship in the empirical model leads from the risk related agreements to the level of task division. This connects to the theory part where a higher level of interdependency also connects to a higher alliance failure risk. With task division as a means to reduce the reciprocal interdependence in an innovation alliance the negative connection can be explained by the argument that less risk related agreements are needed in cases of reduced interdependency due to a higher level of task division. No further relations where found between structural and relational governance constructs, which leaves Hypothesis 3 unconfirmed (For an overview of the hypotheses see Table 4.5).



Path significant at alpha = 0.06 level
Path significant at alpha = 0.05 level
Path significant at alpha = 0.01 level

-* negative path coefficient

Figure 4.2. Significant paths in the PLS model of innovation alliances

4.5 Discussion and conclusions

The present chapter aims at analyzing the different stages in the innovation alliance collaboration process to identify the key factors influencing alliance performance. A higher alliance potential leads to a higher chance of positive alliance performance, especially if the structural governance mechanisms in terms of a clear task division, to lower the level of interdependency in the alliance, allows for an efficient use of a company's core resources. The best results are reached if this is combined with clear up-front structural agreements in the alliance formalization phase to create a platform on which relational governance can strive, easing coordination in the alliance execution phase, and therewith positively influencing alliance performance. The importance of the alliance to the respondent's company, as indicated by the number of staff working on alliance activities, was positively related to the level of risk related agreements, and not to input and output related agreements, indicating that it is especially the level of risk that a company in an alliance wants to reduce. Relational trust makes the communication among alliance partners easier and leads to a higher level of knowledge exchange. The communication level positively influences the knowledge exchange in an alliance. Frequent communication and shared codes are factors building trust (Omta and Van Rossum, 1999). A higher relational trust positively relates to alliance outcomes and ultimately to alliance satisfaction.

Table 4.5 Results for the hypotheses testing

Hypothesis 1: In a successful innovation alliance a higher level of complementarity of material and immaterial resources will be positively related to a higher level of task division.	Hyp. 1: Confirmed
Hypothesis 2: A higher importance status given to the alliance will be positively related to a higher level of structural agreements.	Hyp. 2: Confirmed*
Hypothesis 3: In a successful innovation alliance structural (contractual and non-contractual) agreements are needed to provide an assurance platform on which relational governance mechanisms can strive.	Hyp. 3: Not confirmed
Hypothesis 4: In a successful innovation alliance the frequency of communication will be positively related to relational trust (4a), while the increasing relational trust will help to ease the communication among the alliance partners (4b).	Hyp. 4a: Not confirmed Hyp. 4b: Confirmed
Hypothesis 5: In a successful innovation alliance the combination of structural and relational governance mechanisms will be positively related to knowledge resources exchange.	Hyp. 5: Confirmed
Hypothesis 6: A higher level of task division will allow enhanced resources exchange in the alliance collaboration.	Hyp. 6: Confirmed
Hypothesis 7: The level of (knowledge and material) resources exchange will be positively related to alliance outcomes (7a), whereas alliances outcomes will be positively related to alliance satisfaction (7b).	Hyp. 7a: Confirmed Hyp. 7b: Confirmed

* Confirmed for risk related agreements

Resources exchange, in terms of knowledge and material resources, can be regarded as the core of alliance execution. Trust is needed as a prerequisite to allow a higher level of communication. While communication frequency is not necessarily trust dependent, the ease of communication certainly is. If the doors to key persons are locked this limits alliance execution. Clear upfront agreements work to lower or even diminish the risk perception of the partners concerning the leaking of confidential information by providing assurance to each of the alliance partners that the other(s) will not act opportunistically. So structural governance mechanisms work as a door opener, allowing relational trust and a higher communication level, increasing knowledge exchange within an alliance. The study does not support the statement of De Man and Duysters (2005) that *alliances with similar companies have more potential for innovation.* Partners with a higher resource complementarity reported on average a higher alliance performance. This is in line with the findings of Keil et al. (2008), who compared intra-industry alliances with related industry and non-related industry alliances. Still, a higher level of complementarity of material and immaterial resources, which implicates a larger cognitive distance, also means a bigger challenge for the knowledge exchange within the alliance, which requires, in line with the findings of De Man and Duysters (2005), to build up good alliance management capabilities. In this respect, the identification of the alliance formalization phase as a necessary stage in the alliance collaboration process anteceding knowledge exchange, contributes to the research needs as indicated by Easterby-Smith et al. (2008) and Van Wijk et al. (2008). In this way the study extents the findings of Poppo and Zenger (2002) by showing a limited substitutability between structural and relational governance mechanisms within innovation alliances. The exploratory case study findings of Tepic et al. (2013) concerning the role of structural and relational governance in innovation projects could be empirically tested in the presented alliance collaboration model, and the importance role of structural governance as a solid basis for creating trust, especially in alliances in which the partners do not know each other, was clearly shown.

An innovation alliance is described as a high (reciprocal) interdependence collaboration. The results of this study have shown that lowering the level of mutual interdependency by task division combined with a high level of resource exchange was positively related to alliance performance. Therewith the findings of this study challenge the conclusions of Sambasivan et al., (2011) who found a positive relationship between task interdependence and trust, commitment and communication. They are in line with those of Batterink (2009: 70) who found that a clear task division is a *successful way to improve innovation performance* in an innovation alliance, due to a more efficient use of alliance resources. The empirical test in the presented alliance collaboration model supports these findings of Batterink (2009). The presented results are also in line with the findings of Victor and Blackburn (1987) who reported negative effects with increased interdependency due to the increased contingencies that have to be managed. In literature (see e.g. Goh, 2002) frequent contacts are stressed to be important for knowledge exchange. This chapter leads to the same conclusion, since tacit knowledge transfer is positively related to communication frequency (by e-mail, telephone and face-to-face contacts).

From the group comparison, a number of preliminary conclusions can be derived. Knowledge institutions are chosen over companies for innovation alliances with a rather explorative character. The communication frequency and therefore probably also the collaboration interdependence is lower, while the communication lines are opener. As one of the interviewees remarked: *When contacting a knowledge institution there are almost no restrictions on who to speak to.* The alliances by SMEs outperformed the alliances by big companies, although there were less upfront agreements and fewer people involved in the alliance collaboration. Also the resource complementarity with the alliance partner is bigger for SMEs. SMEs clearly seem to transform this higher alliance potential into a higher alliance value creation effectively, which confirms the findings of other authors (see e.g. Nooteboom, 1994, Nooteboom and Vossen, 1995). Concerning the sector differences, it can be concluded that the green- and pharma-biotech use more structural governance mechanisms, make more upfront agreements, especially concerning intellectual property (IP) and use more technology mapping to keep track on it, than the nano-tech and food companies. At least for the pharma biotech it can be concluded that this results in lower opportunism and a higher willingness to cooperate again with the same partner. Therefore the biotech sector seems to tackle the 'outlearn the partner problem'(Hamel, 1991) in a more systematic way compared to the other sectors, which could be related to the need to constantly engage in new alliances to continue innovation. Based on the significant group differences found it can be further concluded that knowledge valorization has a more formal character in the biotech sector, while there is a tendency to a less formal approach when it comes to SMEs.

Chapter 5

Knowledge valorization in a public-private research partnership[6]

5.1 Introduction

Stimulating innovation stands high on national and supranational political agendas. Innovation involves the conversion of new knowledge into a new product, process or service and bringing this new product, process or service into use (Johnson et al., 2008). Since innovations are increasingly being established within inter-organizational networks (Coombs et al., 2003, Powell et al., 1996) and resulting from recent success stories of so-called open innovation (Chesbrough et al., 2008), governments are searching for new ways to stimulate innovation by involving the public and private sector and stimulating partnerships between them (e.g. Audretsch et al., 2002), a concept referred to under Section 1.2.1 as a triple helix network. Public private research partnerships (PPRPs) aim to combine *"the resources of government with those of private agents (business or not-for-profit bodies) in order to deliver societal goals"* (Skelcher, 2005). Since the resources of government include the publicly-financed research organizations, knowledge is one of the main resources that is brought into the partnerships from the public side to transform it into value for society (Perkmann and Walsh, 2008).

PPRPs aim therefore, to enhance knowledge valorization by the participating public research organizations and by participating companies, which is by definition, the formal transfer of knowledge resulting from basic or applied research to the commercial sector for economic benefit (Goorden et al., 2008). In the literature examples of large PPRPs are found, such as SEMATECH, established in the USA with 100 Million dollars of federal funding in 1987 to regain a leading position in computer manufacturing by combining private and governmental know-how (Geisler, 2001). Recent studies show a widespread use of university-industry partnerships in Austria (Schartinger et al., 2002), the United Kingdom (D'Este and Patel, 2007) and Germany (Meyer-Krahmer and Schmoch, 1998).

However, there are also some concerns about the effectiveness of PPRPs. Adams (1990) found a time lag of approximately 20 years between starting research and the moment that industry can profit. Geisler (2001) argues that gains from PPRPs appear mainly to lie in leveraged R&D rather than in the number of product innovations, while Feller (2005) claims that firms, by establishing

[6] This chapter is based on Garbade, P.J.P., S.W.F. Omta, Fortuin, F.T.J.M., R. Hall and G. Leone, (2013), The impact of the product generation life cycle on knowledge valorization at the public private research partnership, the Centre for BioSystems Genomics, *NJAS Wageningen Journal of life sciences,* 67, 1-10.

relationships with universities, aim for generic benefits, such as coming into contact with young researchers who are possible future employees, rather than to commercialize scientific innovations. Although these generic benefits are important, these concerns bring up the research question: ‘Do PPRPs really increase the level of knowledge valorization by companies?’ An additional question is, whether the effectiveness of knowledge valorization by companies in PPRPs can be expected to be independent of contingencies or instead, are dependent upon certain parameters, such as company size (Fontana and Geuna, 2005, Santoro and Chakrabarti, 2002) or type of industry sector (Widdus, 2001). A further interesting parameter to be taken into account is the length of the product generation life cycle (PGLC), which is the sum of the product life cycle of all related products belonging to one product generation. Fortuin (2007) identified the PGLC in a cross-industry study as the dominant factor affecting the entire innovation process, from knowledge generation up to market introduction of the final product. This raises the question whether the length of the PGLC also has an impact on the effectiveness of PPRP's. One related research question consequently is: ‘Does the PGLC length of participating companies influence the knowledge valorization process in a PPRP?’

The present chapter investigated these research questions in the Centre for BioSystems Genomics (CBSG), a Dutch PPRP in plant genomics, involving breeding companies active in typically long as well as short life cycle products.

Chapter 5 is structured as follows. Section 5.2 describes the theoretical foundation of the study which provides the basis for the development of a conceptual model. Section 5.3 describes the study domain, Section 5.4 the development of a survey, the methods of data collection, analysis used and the operationalization of the conceptual model. Section 5.5 presents the results of the survey of the CBSG member companies. Finally, in Section 5.6, the results are discussed and conclusions are drawn.

5.2 Theoretical framework

5.2.1 Knowledge valorization

Knowledge is generated in both public and private organizations but is driven by different motivations in the different organizations. For private organizations, the economic needs and / or the profit orientation can be assumed to play a major role. So they focus more on applied research and the exploitation of knowledge, which is by definition concerned with the refinement and extension of existing technologies (Lavie and Rosenkopf, 2006). Public research in contrast, is free of economic needs, although this view can be questioned (Partha and David, 1994) since public research institutions are increasingly being judged on their economic performance. Up to 25% of academic research is expected to be influenced directly by industrial funding (Behrens and Gray, 2001). The fact that public research is largely financed by national or supranational institutions such as the EU, gives the research a certain direction and tries to align it with the needs of society. In most cases it has a fundamental character and therefore, is related to exploration and investigation, which is rooted in the quest for new knowledge (March, 1991) that can help tackle previously unresolved problems (Perkmann and Walsh, 2009). Entrepreneurship is the most important factor concerning the transfer of this new knowledge to the market (Audretsch and Keilbach, 2007). Exploitation of results by developing new products and bringing them to commercial markets is therefore, expected to be conducted better in private organizations. Knowledge valorization offers the tools for bridging the gap between exploration and exploitation of research results and therefore, it seems there are evident advantages in combining these strengths of public and private organizations in PPRPs. This applies especially to science-based sectors such as biotechnology. These show high complementarities between academic research and commercial R&D (Perkmann and Walsh, 2008), a high importance status of university generated IP (Mansfield, 1995) and provision of company staff by universities (Partha and David, 1994, Faulkner et al., 1995).

Access to networks and proximity of knowledge are key to trigger innovation (Piet Schalkwijk, IPR director of Akzo Nobel, 2010[7]). Therefore, to be excluded from knowledge access could mean a large competitive disadvantage for companies. In a competitive business environment a potential risk for innovation occurs when some (especially small) companies are excluded from the network and therefore from knowledge access. PPRPs can increase a companies' innovative reputation (Hicks, 1995) and balance out a knowledge access blockage that companies might face by allowing also smaller companies to participate and thus benefit from the knowledge created. Consequently, in science-based sectors, many firms stimulate industrial researchers to interact with academia, and also join forces to generate sufficient critical mass (Cockburn and Henderson, 1998).

One form of knowledge valorization in PPRPs includes agreeing upfront about the companies' right to use the research results for commercial exploitation for a certain license fee (Feller, 2005). Typically, these fees are limited as both the public (universities and research institutes) and the private (company) partners contribute to the research. While knowledge is normally published by publicly financed researchers without claiming any exploitation rights to it (Murray and O'Mahony, 2007), in PPRPs knowledge exploitation rights may need to be distributed according to the partners' contribution to the research or relating to monetary issues. This needs to be justified to the taxpayer, who does not have an interest to finance research and transfer the rights of research results at a low cost price to one or several exploiting parties, aiming to generate profits from them. This justification can be found in the gains in the exploitation efficiency of the generated knowledge, so that society in general, can finally benefit from a technology or product that would not be developed otherwise.

This efficiency increase or net economic benefit has however, yet to be proven (Audretsch and Keilbach, 2007), so in order to justify the potential privatization of formerly public knowledge, this step has at least to result in a better performance of the companies participating in PPRPs, compared to companies that do not. If intellectual property rights (IPRs) are supposed to show value in the knowledge valorization process, they are supposed to generate, besides the exclusive exploitation rights to the organization owning them, also a broader knowledge base to conduct further research for the whole research community. This can be achieved when the IPRs are vested at the public research institutes. In the specific case of plant breeding, where the IPRs are granted in the form of plant breeders rights (PBRs), the research exemption would also grant such an additional benefit to the researchers' community, since the PBR holder is always obliged to provide samples of the protected plant varieties to parties planning to conduct further research on them.

5.2.2 Impact of the length of the product generation life cycle (PGLC)

The product generation life cycle (PGLC) is built on the well-known concept of the product life cycle (PLC). Bayus (1994) defines the product life cycle as the evolution of unit sales over the entire lifetime of a product. The product life cycle (e.g. Cox, 1967, Levitt, 1965, Polli and Cook, 1969, Moore, 1999) has four stages: introduction (an initial period of slow sales growth), growth (a period of rapid growth in sales), maturity (a period in which sales level off and are relatively stable), and decline (when sales drop off). Maidique and Zirger (1985) introduced the concept of the product generation life cycle (PGLC) as being the sum of the product life cycles of all related products belonging to one product generation. Across industries, huge differences in the average length of the product generation life cycle (PGLC) of products can be observed, ranging from less than one year, such as in the mobile phone and computer industry, to over 20 years, such as in the pharmaceutical and aircraft industries (Williams, 1999). Fine (1998) and Brown and Eisenhart (1998) refer to these differences as 'industry clock speed'.

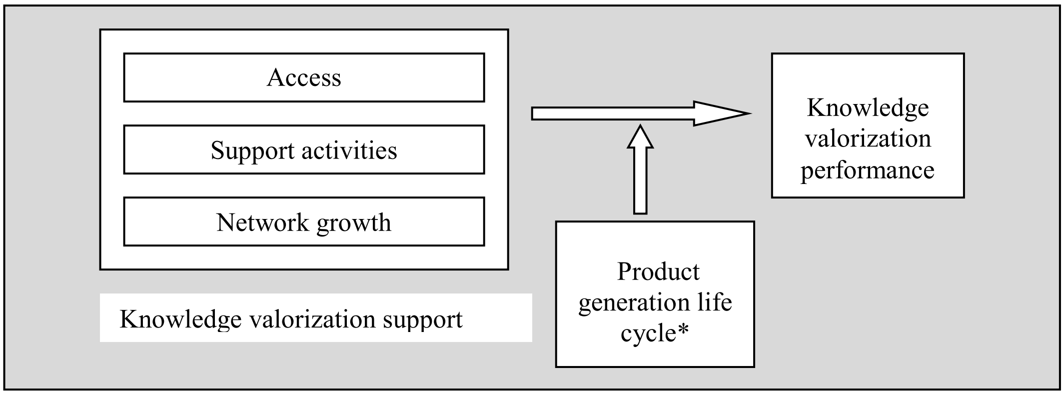
[7] Own observation 2010

In a cross-industry study of 10 multinational technology-based companies Fortuin (2007) investigated the impact of the length of the product generation life cycle on the innovation process. The length of the PGLC proved to have a major impact on the entire innovation process from the knowledge generation in basic research up to the market introduction of the final product. In typically long life cycle industries, companies are generally confronted with high technological complexity, leading to an elongation of the research part of the innovation process. Companies in industries with relatively short PGLCs are typically confronted with a high level of market dynamism and competition leading to extra pressure to speed up the R&D process in order to shorten the time-to-market.

Companies with shorter PGLCs are more bothered by the speed at which things develop compared to companies with longer PGLCs. Receiving information in time and not to miss out on opportunities should play a much more prominent role, which is supposed to determine a high importance of knowledge access and knowledge transfer within a PPRP structure. Since public research institutes build on the curiosity and economical independency of their researchers, they represent a valuable pool to tap for a diversity of up-to-date information on a wide range of knowledge fields. For companies with a long PGLC, the possibility to reduce the product development time by involving publicly generated knowledge could be an effective way to valorize knowledge generated in a PPRP context.

In the plant breeding industry, major differences exist in PGLC length. These will be discussed for potato and tomato breeding companies in Section 3. Since both types of company participate in CBSG, this provides a unique opportunity to study the impact of the length of the PGLC on valorization within one industry sector.

Our hypothesis leads to the conceptual model as represented in Figure 5.1 below. In this model the knowledge valorization support as provided by the PPRP is conceptualized as consisting of access, support activities and network growth enhancement. The knowledge valorization support is supposed to result in a knowledge valorization performance. In this relationship, the PGLC is supposed to have a mediating effect.



* PGLC proxy: tomato has a short, potato has a long PGLC

Figure 5.1. Conceptual model: Knowledge valorization in a public private partnership

5.3 Study domain

5.3.1 Centre for BioSystems Genomics (CBSG)

In the Netherlands the traditional agricultural knowledge valorization model, has been based on co-financed research initiatives connecting public and private research. From the 1990s, the Dutch government initiated the set-up of networks of public research and industry organizations in specific technology areas (OECD, 2003). As a consequence the old model has been increasingly replaced by establishing PPRPs on research programs (Spiertz and Kropff, 2011). CBSG is an example of a Dutch PPRP in plant genomics, including 4 universities and two research institutes, 6 vegetable seed breeding companies, 5 potato breeding, 1 potato processing company, 1 genomics technology company and 2 potato commodity boards. CBSG aims to exploit the full potential of a broad range of genomics approaches in order to create new opportunities for sustainable crop production, enhanced food quality with reduced environmental impact. Research is focussed around a fully-integrated research programme targeting potato, tomato and, to a less extent, Brassica crops. CBSG was established in 2002 with a total research budget of 53 M€ for 5 years. In 2008, CBSG entered its second 5 year period with an equivalent budget. Some 15 % of the CBSG total budget is paid by the private partners. CBSG carries out plant genomics research using the latest, state-of-the-art technologies. The limited choice of crops has deliberately been made to maintain focus and to cover the species of greatest importance for the Dutch agro-food industry.

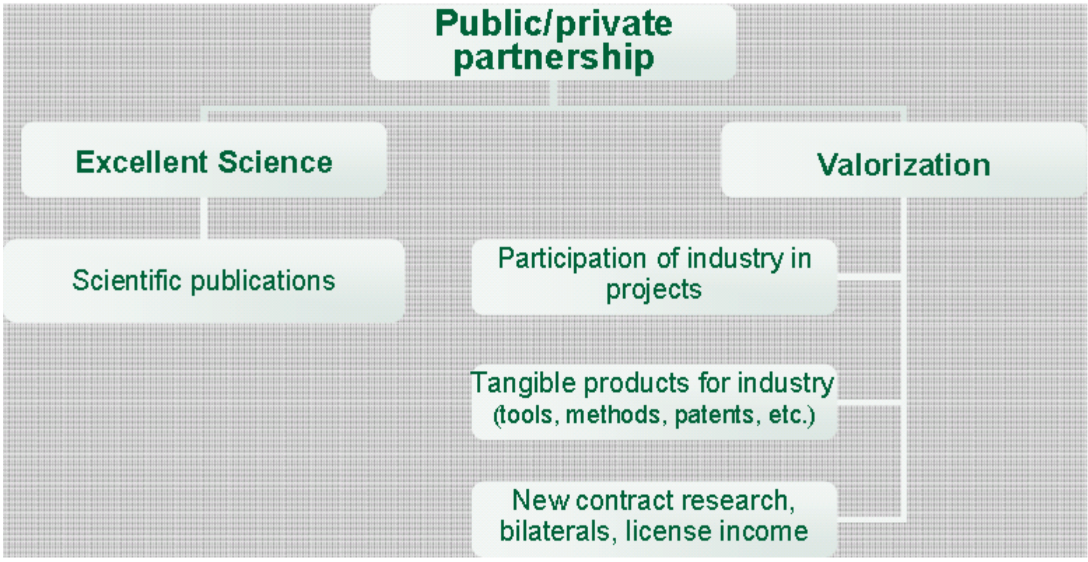


Figure 5.2. Main objectives of Centre for BioSystems Genomics (Leone, 2011)

5.3.2 Public private research partnerships (PPRPs) in the breeding industry

Collaborative research and informal contacts are more important in the plant breeding field compared to other, more applied fields of technology production (Meyer-Krahmer and Schmoch, 1998). Therefore it is not surprising to find Dutch plant breeding companies engaging in a number of different PPRPs with knowledge institutions. A PPRP, such as CBSG, has to serve different stakeholders. The knowledge institutions, the companies and, last but not least, society have to benefit from the PPRP. The knowledge institutions expect that excellent science will take place, resulting in a large number of highly rated scientific publications, which is the primary performance indicator they are measured against. They also expect the PPRP to result in new contract research, bilateral research agreements and last but not least, also in the generation of extra income by licensing out their intellectual property rights (IPRs) to industry. Industry in turn expects that their participation in a PPRP results in tangible products in the form of tools, methods, and products etc. which they can use, as schematically presented in Figure 5.2. Society (tax payers and government) expects results both in science and education (including training high quality researchers and PhDs), as well as valorization in terms of new, improved products that are important for society and induce extra employment.

5.3.3 Tomato versus potato breeding

Many of the world's leading plant breeding companies have their headquarters and/or important R&D facilities in the Netherlands (Louwaars et al., 2010). The CBSG partners are companies that are in the top 10 tomato seed companies operating worldwide. The main Dutch potato companies operate in the Dutch, European, and global potato markets. While some tomato seed companies are also powerful multinationals; they all develop seeds not only for tomato, but also for other important vegetables, e.g. for cucumber, cauliflower and pepper. The potato breeding companies focus instead only on seed potato production. The partners in CBSG cover ca. 85% of the global fresh tomato seed market and 75% of seed potato production.

The differences between potato and tomato breeding companies start from the biological differences in the plants, especially in the way the crops are propagated and cultivated. Diploid tomato cultivars require 3 to 8 years to be bred which allows them to reach their commercial peak before 25 years (plant breeding protection time). Tomato seeds are sold as F1 hybrids, implicating that the next generation will not inherit the same traits, so F1 hybrids can work as IP protection. Due to the complex tetraploid genome, potatoes require 10 to 20 years to be bred and propagated ready for release. Twenty five years is therefore too short for a potato cultivar to be profitable, so plant breeders rights (PBRs) have been extended to 30 years. For potatoes, molecular breeding possibilities and therefore the steering capacity of the breeding process is currently limited compared to tomato molecular breeding. Tomato and potato companies show consequently a tremendous difference in PGLC length, which makes them an ideal study population to answer our research question 'Does the PGLC length influence the knowledge valorization process in a PPRP?'

In the Netherlands, tomatoes are grown under controlled conditions in greenhouses. Therefore tomatoes are more readily protectable and hence, are subjected to lower disease pressures. Furthermore, many current varieties already carry important disease resistances and therefore, breeding can focus more on qualitative traits: taste, fragrance and appearance. Potatoes in contrast, are vegetatively-propagated and cultivated in open fields. As a consequence, potato breeding is strongly directed towards resistance to devastating diseases such as late blight (*Phytophthora*).

5.4 Methods

In 2009 a research project was conducted with the aim of assessing how effective CBSG has been in valorizing its fundamental and applied research results in which all CBSG member companies participated. As done by Perkmann and Walsh (2007), the research is not based on publically available intellectual property (IP) databases but on a company survey used so as not to miss out on collaborative aspects and results that do not occur in IP databases. From the companies, interviewees were selected based on their involvement in CBSG: they were contact person, project leader, or member of the CBSG management team. Within their organizations the participants fulfill one or more roles as: researcher, breeder, R&D manager, or director. The valorization of knowledge was evaluated by means of a 207 item questionnaire. The questions were a mix of closed questions that used 7-point Likert scale, and open questions in which quantification of the CBSG's valorization support was requested. There were questions regarding CBSG access and support, frequency of use of CBSG services and CBSG related performance to link PPRP specific inputs and outcomes directly (Perkmann et al., 2011). The questions used are given in Table 5.1.

Table 5.1. Summary of variables used in the questionnaire

<u>Below per indicator two questions are asked regarding CBSG support (unless otherwise introduced).</u>

1.) **How important is _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ for your organization?** 1: not important ; 7: very important
2.) **Which value describes best the frequency of use 2003-2008?** 1: never, 2: once per 3 years, 3: once per year, 4: once per quarter, 5: once per month, 6: once per week, 7: daily

		Indicators	
Knowledge valorization support	Access	**Contact with CBSG researchers**	Contact with qualified CBSG researchers
		Intranet	Access to CBSG intranet information
		Databases	Access to databases
		Access to IP	Help with getting access to Intellectual Property (licenses, plant breeders rights, patents)
		International research programs	Access to information on international research programs
		Summit	Access to the annual CBSG summit
		Infrastructure	Access to infrastructure (e.g. R&D labs, equipment, instruments)
	Support activities	**Technology monitoring**	Help with new technology monitoring and road mapping
		Technology advice	Access to technology advice
		IP filing	Help with Intellectual Property filing (plant breeders rights, patents)
		Bio-informatics	Access to bio-informatics knowledge and services
		Troubleshooting	Help with troubleshooting
		Sharing R&D costs	Possibility to share R&D costs with other companies (conducting research collectively with CBSG partners)
		Recruiting new researchers	Participating in the CBSG program enables my organization to recruit new researchers or assistants (1: completely disagree; 7 completely agree)
	Network growth	**Company interaction**	Enhanced interaction with other companies in the potato / tomato sector
		Bilateral research	Help to set up bilateral research program with other CBSG partners
		Has CBSG support led to extra research within the CBSG framework?	
		Extra research with knowledge institutions	Percentage extra research with knowledge institutions within CBSG (%)
		Extra research with commercial partners	Percentage extra research with other commercial partners within CBSG (%)

	Indicators	**Please indicate the extent to which you agree with the following statements:** Likert scales from 1 to 7 : 1: completely disagree, 7: completely agree
Knowledge valorization performance	**Basic research**	By participating in the CBSG program my organization expects to improve the basic research process.
	Plant breeding	By participating in the CBSG program my organization expects to improve its breeding process.
	Successful research completion	Participating in the CBSG increases the chances of successful research completion
	Breeding strategy	Participating in the CBSG program enables my organization to improve its breeding strategy.
	Breeding time reduction	Please quantify the percentage of the breeding process time reduction (%)

	Tested markers	Participating in the CBSG program enables my organization to increase the number of tomato/potato markers that will be tested.
	New products developed	Participating in the CBSG program enables my organization to develop new products.
	New products launched	By participating in the CBSG program my organization expects to launch new products to the market.
	Valorization level	In general which grade would you assign to the valorization of the CBSG research resulting from the participation in the CBSG program? 1: very low; 7: very high
	Strengthened image	Participating in the CBSG program enables my organization to strengthen its image
	Knowledge and skills	Participating in the CBSG program enables my organization to improve the level of knowledge and skills of the personnel.

In total, 15 questionnaires were analyzed, one for each private partner. These have been categorized according to the type of industry, place in the value chain, and the size of the organization. Since the data are non-parametric, the questionnaire input has been analyzed by using Spearman rank correlation and Kruskal Wallis–tests.

5.5 Results

5.5.1 Baseline description and CBSG output

Seven of the participating companies belong to the tomato industry and eight belong to the potato industry. Thirteen companies (7 tomato companies and 6 potato companies) are directly involved in breeding, while one potato company has a daughter company conducting the breeding activities. Two partners participating in CBSG have their core activities in processing. Twelve organizations (7 tomato companies and 5 potato companies) are large firms (annual sales > 100M€), and three (potato companies) are small firms (annual sales < 50M€). The list of participating organizations can be found on the CBSG public website: www.cbsg.nl.

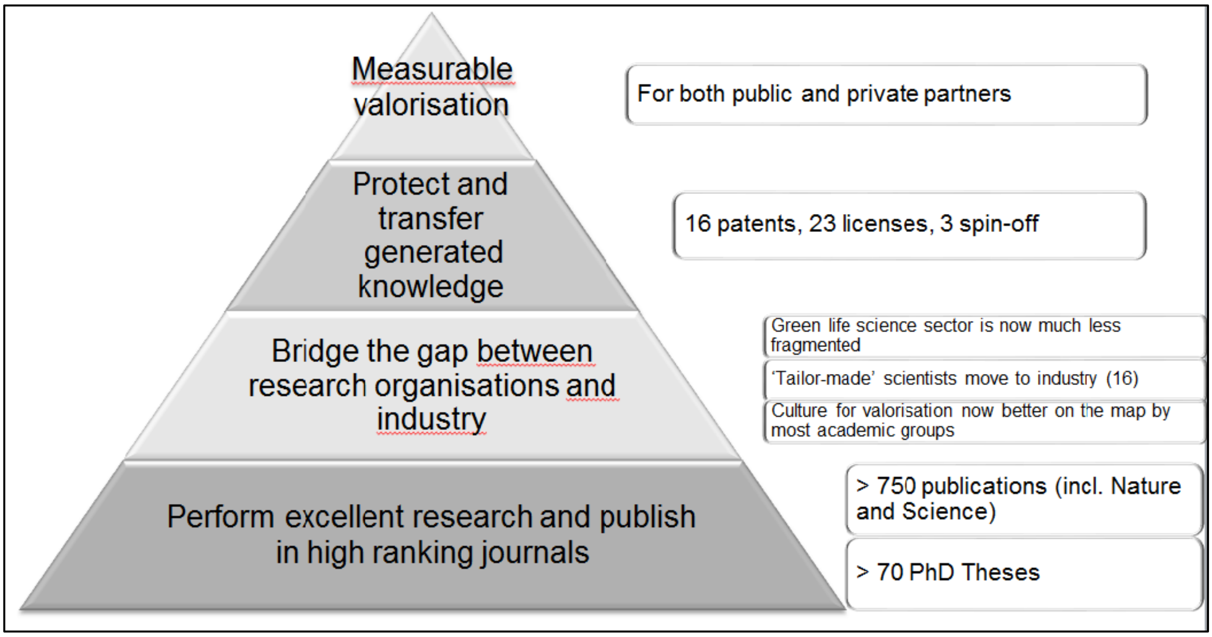


Figure 5.3. Centre for BioSystems Genomics 2002-2012 output overview (Leone, 2013)

Figure 5.3 shows the output of CBSG in the period 2002-2012. CBSG was considerably successful in terms of its scientific output, with more than 750 scientific publications, including papers in Science and Nature and more than 70 successful PhD defenses. In terms of knowledge valorization, 16 patents were filed, 23 licenses were awarded and three spin off company was established. In the interviews, six companies indicated that up to four new products could be developed as a result of the CBSG activities. Up to 100 tomato/ potato genetic markers potentially useful for breeding could be tested and are expected to be implemented. One company further indicated that CBSG participation could lead to 10 new varieties. Another company indicated that 90% of future products will be derived from CBSG activities.

5.5.2 Knowledge valorization at CBSG

To shed light on the knowledge valorization and the effect of the PGLC length the results as reported in Table 5.2 are discussed.

Table 5.2. Mean and standard deviation and significant Spearman rank correlations of potato (P, n=8) and tomato (T) companies (n=7)[8]

Indicator			Mean (Stdv)	Knowledge valorization performance										
				1	2	3	4	5	6	7	8	9	10	11
1	Basic research	P	**5.3*** (1.8)	x										
		T	3.4 (1.7)	x										
2	Plant breeding	P	**5.3*** (1.9)	.95**	x									
		T	2.2 (1.5)		x									
3	Successful research completion	P	3.9 (1.6)	.56		x								
		T	4.1 (1.7)	.64		x								
4	Breeding strategy	P	**5.3*** (1.8)	.69	.75*		x							
		T	2.7 (1.9)		.62	.80*	x							
5	Breeding time reduction	P	**19%**(18%)	.89*	.95**		.80	x						
		T	No time red.					x						
6	Tested markers	P	**6.3*** (0.5)				.66		X					
		T	3.7 (2.4)						X					
7	New products developed	P	4.3 (2.1)						.67	x				
		T	4.0 (2.2)						.64	x				
8	New products launched	P	4.5 (1.8)	.73*	.64	.67*	.94**		.85*	.69*	X			
		T	3.8 (2.3)			.67	.62			.99**	X			
9	Valorization level	P	4.6 (1.5)	.75*		.78*	.72		.67	.73*	.85**	x		
		T	3.6 (1.5)	.59		.82*	.62					x		
10	Strengthened image	P	4.5 (1.6)	.83**	.72	.70*	.69			.61	.76*	.93**	x	
		T	4.0 (2.2)									.77*	x	
11	Knowledge and skills	P	6.0 (0.7)		.78*	.60								x
		T	4.7 (1.9)			.66								x
Indicator			**Mean (Stdv)**	**Knowledge valorization support**										
				1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Contact with CBSG researchers (importance)		P	5.0 (1.7)		.84*		.87*	.86*						.68*
		T	5.8 (0.9)		.64	.56	.73*		.75*	.86*	.85*			
Contact with CBSG researchers (frequency)		P	4.4 (0.9)											
		T	4.3 (0.5)							-.89*	-.87*			
Intranet (importance)		P	6.3 (0.7)						.61					
		T	5.9 (1.1)											
Intranet (frequency)		P	5.3 (0.7)	.85**	.72			.89*					.62	.51
		T	4.4 (1.1)								-.71		-.64	
Databases (importance)		P	4.8 (1.6)	.80**	.78*	.66*		.86*			.65*	.69*	.82**	
		T	5.1 (1.9)	.79*		.63						.60		
Databases (frequency)		P	4.0 (2.1)	.62	.66			.95**						
		T	4.0 (1.3)	.94**		.68*						.56		.63
Access to IP (importance)		P	2.8 (2.0)							.54		.57	.67*	
		T	3.0 (2.2)	.62						.80*	.74*			
Access to IP		P	1.5 (0.9)					.73						

[8] A number of breeding specific knowledge valorization performance questions (number 2,4,5,6) were not applicable to the potato processing companies, which reduces the potato companies sample to 6 companies for these questions.

(frequency)	T	1.1 (0.4)			.64								
International research programs (importance)	P	3.8 (1.6)											.64*
	T	4.9 (1.7)		.75*				.67					
International research programs (frequency)	P	3.3 (1.3)	.87**	.94**	.63*	.61	.82*			.72*	.64*	.68*	.79*
	T	3.6 (0.9)										-.80	
Summit (importance)	P	3.8 (1.8)			.65*				.66*	.54	.79**	.71*	
	T	5.7* (1.7)			.60	.78*							
Infrastructure (importance)	P	3.9 (1.8)	.83**	.77*	.75*	.84*			.66*	.87**	.92**	.96**	
	T	4.1 (2.2)	.59					.74*	.74*	.64			
Infrastructure (frequency)	P	3.0 (1.8)	.75*					.67		.59			
	T	2.2 (1.7)						.62					
Technology monitoring (importance)	P	**4.5** (1.9)							.75*		.69*	.72*	
	T	2.7 (1.5)											
Technology monitoring (frequency)	P	**2.8** (0.9)						.66	.55		.51		
	T	1.9 (0.9)											
Technology advice (importance)	P	3.4 (1.8)	.79**	.91**	.80**	.75*	.79			.83**	.70*	.73*	.56
	T	4.0 (1.6)											
Technology advice (frequency)	P	2.3 (1.0)											
	T	2.7 (1.4)									.72*	.90**	
IP filing (importance)	P	1 (0)											
	T	2.3 (2.2)						.59	.67				
IP filing (frequency)	P	1.1 (0.4)	.51			.70	.73	.63		.60		.51	
	T	1 (0)											
Bio-informatics (importance)	P	4.5 (2.0)	.74*		.56		.76		.69*	.74*	.81**	.89**	
	T	4.6 (2.0)	.63										
Bio-informatics (frequency)	P	3.0 (1.8)	.52				.79					.68*	
	T	3.3 (1.5)											
Troubleshooting (importance)	P	2.3 (1.3)						.88*	.88**	.69*	.59		
	T	1.7 (1.3)						.59	.67				
Troubleshooting (frequency)	P	2.1**(1.0)											
	T	1.0 (0)											
Sharing R&D costs (importance)	P	6.1**(0.8)											
	T	3.4 (2.0)		.67	.56	.67					.57	.56	
Recruiting new researchers	P	3.9 (2.1)	.82**	.97**	.69*	.76*	.87*			.72*	.68*	.73*	.70*
	T	4.0 (2.2)									.67	.71*	
Company interaction (importance)	P	4.0 (2.4)		.81*		.92*	.89						.72*
	T	3.6 (1.7)	.60					.62					
Company interaction (frequency)	P	4.4* (0.8)											
	T	2.7 (1.5)									.60	.74*	
Bilateral research (importance)	P	2.6 (1.8)							.92**	.67*	.61	.60	
	T	3.1 (1.2)		.72		.66		.85**					
Bilateral research (frequency)	P	1.9 (1.2)				.69		,85*	,86**	,76*	.58		
	T	1.7 (1.0)											
Extra research with knowledge centers	P	6.3% (11%)	,73*	.84*		.81*	.90*			.69*	.63*	.81**	
	T	0.1% (0.2%)											
Extra research with commercial partners	P	**2.4%** (3%)		.80	.67								.63
	T	No extra res.											

Shaded = questions with significant mean differences (1-tailed) between potato and tomato companies are shaded grey.
Blank = no correlation at least at the 0.1 level (1-tailed); No star = Correlation is significant at the 0.1 level (1-tailed)
*Correlation is significant at the 0.05 level (1-tailed); **Correlation is significant at the 0.01 level (1-tailed)

First, the means of a number of answers given by tomato and potato companies with focus on significant differences between the two types of companies are compared by applying a Kruskal Wallis test on two independent samples (vertical dimension in Table 5.2). Then, the parameter 'knowledge valorization performance' has been related to the parameter 'knowledge valorization support' activities. By looking at the correlations found for the potato and tomato companies separately, it has been extrapolated where both company types show a similar pattern and where there are differences that can be related to the PGLC length (horizontal dimension in Table 5.2).

When looking at the mean differences of potato and tomato companies in terms of knowledge valorization performance, Table 5.2 (vertical dimension in table) shows a significant difference between the results found for the indicators 'improvement of the basic research', 'plant breeding' and 'breeding strategy'. The potato breeders agree with the statement that from their participation in the CBSG program, they expect an improvement in basic research and plant breeding, and state that CBSG participation has enabled a breeding strategy improvement. The tomato companies slightly disagree with these statements. These results should be seen within the perspective of the learning potential towards these processes, since the tomato companies already have more molecular breeding facilities in house. The higher importance of breeding strategy improvement for the potato companies seems also linked to the higher complexity of their own breeding process. When it comes to the indicator 'time reduction in the breeding process', potato breeding companies indicate any reduction of 19%, while the tomato breeding companies did not indicate a time reduction. This could be explained by the fact that tomato breeding companies are already close to the minimum, biologically-possible, PGLC length, with further time reductions being much harder to achieve. Another significant difference between the potato and tomato breeding companies is the increase in the indicator 'number of markers' that are tested due to CBSG participation. For other knowledge valorization performance indicators, no significant mean differences were found between tomato and potato companies.

Concerning differences in the knowledge valorization support in Table 5.2 (also Table 5.1 for explanation), at first it should be noted that the parameter 'access' to CBSG was evaluated similarly by potato and tomato companies. Potato companies judge the importance of the indicator 'intranet access' quite high with an average score of 6.3 on a scale from 1 to 7, while tomato companies score this slightly lower with an average of 5.9. The tomato companies judge the importance of indicator 'contact with CBSG researchers' to be as important as the indicator 'access to the CBSG intranet', while the potato companies give a slightly lower score to the indicator 'importance of contact with the CBSG researchers'. When looking at the indicator 'frequencies of the CBSG access', the contact frequency between CBSG researchers and the tomato and potato companies is almost the same, between once per quarter and once per month (data not shown). Potato companies use the CBSG intranet more than once per month, tomato companies about once every two months (data not shown). The CBSG database is used by both company types, once per quarter (data not shown). The only significant difference concerns the indicator 'annual CBSG summit', where tomato companies judge it as important with a score of 5.7 while the potato companies give it a 3.8. When evaluating the parameter 'support activities' provided by CBSG (also Table 5.1), the potato companies give a higher importance to indicator 'technology monitoring and road mapping' and use it significantly more often than the tomato companies. At the same time, the potato companies also accept more frequently the help of CBSG when it comes to the indicator 'troubleshooting' and judge the importance of the indicator 'R&D cost sharing' higher than tomato companies. The importance of the indicator 'R&D cost sharing' seems to be in line with the findings of Fortuin (2007) in that with long PGLC companies, the R&D costs are higher and have to be spread out over a longer time period due to facing higher levels of uncertainty. Tomato companies, with a shorter PGLC, in contrast, value more highly the access to the annual CBSG summit and the CBSG website, which can be related to the fast changing short life cycle innovations. Here, being updated in time on the very latest developments is crucial.

Concerning the effect of the parameter 'network growth' (Table 5.1), the potato companies show a higher frequency with regard to the indicator 'interacting with other companies' - about every two months (data not shown), while the tomato companies assess this item to occur about once per year (data not shown). Potato companies indicate also 2.4% extra research with other CBSG commercial partners, while the tomato companies state no extra research with regard to this indicator.

To see whether the differences found between potato and tomato companies also impact on the role that certain factors have in our valorization model, an in depth analysis was conducted. Therefore, the Spearman rank correlations for tomato and potato companies have been examined separately (horizontal dimension in Table 5.2), throughout all the indicator questions. The expectations towards the indicator ‘basic research improvements’ correlate with the indicator ‘successful research completion’, for both potato and tomato companies. For the potato companies, the high correlation of 0.95** between the indicator ‘basic research’ and ‘plant breeding’ suggests that they see the indicator ‘plant breeding’ as closely related to ‘basic research’. For both the potato and tomato companies the expectations towards the indicator ‘plant breeding’ correlate with ‘breeding strategy improvement’, but correlates only for the potato companies with the indicator ‘expectations to launch new products to the market’. The increase in chances of ‘successful research completion’ correlates for both potato and tomato companies with indicator ‘improvement of the level of knowledge and skills’ of their personnel as well as with the indicator ‘expectations to launch new products to the market’. For the tomato companies this increase also correlates with the indicator ‘breeding strategy improvement’. This last result seems in contrast to the higher importance potato companies give to this indicator. A correlation between the indicator ‘new products developed’ and ‘tested markers’ is found for both the tomato and potato companies. The valorization level correlates positively for tomato and potato companies with the indicator ‘basic research’, ‘successful research completion’, ‘breeding strategy’ and ‘strengthened image’. Correlations with the indicator ‘new products launched to the market’ are found for potato companies only. This reflects the nature of the more applied projects potato companies engage in within CBSG. When relating the parameter ‘knowledge valorization performance’ to the parameter ‘knowledge valorization support’ by CBSG correlations are found for both tomato and potato companies between the indicators ‘basic research’ and ‘database’, ‘infrastructure importance’ and ‘database frequency’, as well as for the ‘bio-informatics knowledge importance’. When looking at the indicator ‘plant breeding’, the potato and tomato companies show significant correlations with the indicator ‘contact with CBSG researchers (importance)’. The indicator ‘successful research completion’ correlates for both tomato and potato companies with ‘importance of database access’ and ‘access to the CBSG summit’. For tomato companies, correlations with the indicator ‘importance of CBSG researchers contact’ and with the ‘frequency of database and intellectual property access’ were also found. The indicator ‘time reduction in the breeding process’ is important for the potato companies with a high number of positive correlations found with knowledge valorization support items. This was assessed to be of no importance by the tomato companies perhaps because these already have large in-house molecular breeding capacities. The indicator ‘tested markers’ is found correlated for both tomato and potato companies to the indicator ‘importance of CBSG infrastructure’ and ‘help with troubleshooting’. For the potato companies, it is also specifically correlated with the indicators ’technology monitoring’ and road mapping frequency’, and with ‘importance of CBSG intranet access’. The indicator ‘new products developed’ due to the CBSG participation was found to correlate, for both potato and tomato companies, with the indicators ‘access to intellectual property’, ‘CBSG infrastructure’ and ‘troubleshooting importance’. However it has to be borne in mind that tomato companies engage in CBSG more at the fundamental research level, which also explains negative correlations found between indicator ‘new products developed’ and ‘new products launched’ and frequency of ‘contact to CBSG researchers’. Regarding the indicator ’improvement of the level of knowledge and skills of companies’ personnel’, correlations were found for the potato companies with the indicators ‘importance of contact with CBSG researchers’, ‘access to intranet’, ‘international research programs frequency’, ‘importance of interaction with other companies’ and ‘the recruitment of new researchers'. For the tomato companies a correlation with the indicator 'frequency of the database use' should be mentioned. The valorization level is correlated for both tomato and potato companies to the indicator 'importance of databases' and 'recruitment of new researchers and assistants'.

The differences found between the answers of the potato and tomato companies in the survey give an interesting insight into their different expectation patterns in CBSG. The short PGLC tomato companies give mainly a high priority to obtain up-to-date information, as they judge the importance of the access to the annual CBSG summit and to the databases very high. The long PGLC potato companies give extra credits to the communication tool offered by CBSG in the form of technology monitoring and road mapping and derive extra value from accessing the CBSG infrastructure as can be seen from 8 positive correlations with the parameter 'knowledge valorization performance'.

5.6 Discussion and conclusions

From the results of our in-depth investigation of the public private partnership (PPRP) CBSG, it can be concluded that such a partnership indeed increases the knowledge valorization level. In general companies showed a high appreciation of the access to knowledge, such as the contact to CBSG researchers, the database, intranet and the CBSG summit meeting, i.e. the exchange of information. They also appreciate particularly some of the CBSG valorization support activities, such as technology monitoring and road mapping, the provided bio-informatics services and network growth. Besides this direct appreciation by the companies, all elements of knowledge valorization support were found related to a higher knowledge valorization performance. Therefore, it is concluded that the research explorative strength of the public institutes combined with the exploitative strength of the private organizations results in a tangible higher level of knowledge valorization performance. At the same time, thorough analysis of our findings gives ample indications that the type of valorization is also affected by the different needs of the companies, in relation to the different lengths of their PGLC. Since companies with different PGLC lengths benefited from CBSG participation, it can also be concluded that the length in PGLC is not a restriction to participate in and benefit from a PPRP. However, according to the length of the PGLC, the knowledge transfer as part of the knowledge valorization process takes place in different ways. Long PGLCs require extra communication tools that focus on the long term R&D process. Companies with short term PGLCs are challenged by the race for new products and not to miss out on opportunities. Consequently, the PPRP is valued here more for networking possibilities and as a provider of the latest technological developments. Potato companies clearly profit from CBSG as a PPRP in terms of their knowledge valorization performance. Tomato companies, with their higher in-house molecular breeding capabilities, value CBSG more for the contact with CBSG researchers and access to the annual CBSG summit. For both potato and tomato companies, the contact with CBSG researchers was found to be an important factor of the knowledge valorization process, and was related to a higher knowledge valorization performance. Potato companies further derive their benefits in the knowledge valorization process from gaining access to CBSG infrastructure, intranet and databases and indicated a successful knowledge transfer. Tomato companies seem to benefit also from extending their need for research in collaboration with other companies within CBSG. Although they stated to be rather indifferent towards the importance of the possibility of sharing R&D cost with other companies (conducting research collectively with CBSG partners), based on the significant correlations found, it seems that the cooperation aspect plays a major role for tomato companies as well. Tomato companies especially benefit through the enhanced company cooperation in the CBSG precompetitive research. The long-term focus of precompetitive research appears to complement their daily business, the development of new tomato varieties. A time reduction in the breeding process applies especially to the long PGLC potato companies, which makes the PPRP, for them, a highly effective means of knowledge valorization.

In conclusion, in contrast to the PPRP efficiency doubt raised by a number of authors, as mentioned in the introduction (e.g. Geisler, 2001), it can be concluded that both potato and tomato companies benefit from their participation in CBSG. Furthermore, the general concerns raised by Adams (1990) about PPRPs - that it would take up to 20 years to transform fundamental research in a way that industry can profit from it, can be refined by this study. The PGLC length reduction achieved due to the participation in a PPRP like CBSG will shorten the time that society will have to wait for new products. This can be seen as the pay back to the tax payers' money invested, and is an additional benefit to the outstanding scientific results obtained in CBSG as well as to its support in educating young science professionals well suited to work either in academia or a commercial research environment.

Chapter 6

Synthesis

As indicated in Section 1.1, it is the main objective of this book to analyze the different governance mechanisms that can be used by stakeholders, such as alliance managers, cluster coordinators and policy makers, to improve innovation alliance and network performance. It has been studied how to address the organizational challenges stemming from innovation within a network, e.g. a cluster of companies, as well as in a specific innovation alliance. From a theoretical point of view, the study adds to the existing literature about innovation management by specifying governance mechanisms on the cluster and alliance level which can enhance innovation performance in inter-firm/co-innovation partnerships. The findings of this thesis aim at deriving recommendations to be applied at the international, national and regional network levels as well as on the innovation alliance level.

Several theories have been employed to shed light on the interplay between innovation management on the level of the innovation network (cluster) and the innovation alliance. In Chapter 2, the innovation system theory has been used to focus on the support of clusters by cluster organizations. In Chapter 3, the resource/knowledge based view helped to specify key success factors of innovation alliances, while in Chapter 4 the governance perspective allowed new insights concerning the employment of different innovation alliance governance mechanisms and how these affect the innovation alliance process. Finally, in Chapter 5, within the public private research partnership (PPRP), the Center for BioSystems Genomics (CBSG), the impact of innovation complexity, as reflected in the length of the product generation life cycle (PGLC), on the requested innovation support provided by the public partner has been studied.

In this chapter in Section 6.1 the different research questions will be answered. In Section 6.2 the contributions of the different studies will be combined to arrive at our overarching scientific contribution. In this section also the limitations of the present study and possible directions for further research will be given. This chapter ends with the recommendations, for alliance managers, cluster coordinators and policy makers in Section 6.3.

6.1 Answers to the research questions

Innovation involves the conversion of new knowledge into a new product, process or service and putting this new product, process or service to use (Johnson et al., 2008). Nowadays, innovations are increasingly conducted in inter-organizational networks (Coombs et al., 2003, Powell et al., 1996). Involving other organizations in the innovation process changes it from a closed (in-house) to an open innovation process. Chesbrough et al. (2008) refer to open innovation as *the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the* *markets for external use of knowledge, respectively*. However, innovation within networks raises the level of complexity, because of the complex interaction between institutions and commercial organizations of different size, capabilities and expertise (Omta and Van Rossum, 1999).

Research question 1

Chapter 2 takes a first step in answering the main research question: how to address the organizational challenges stemming from innovation in inter-organizational settings by focusing on the network (or cluster) level. Well known examples of such formal networks in the high-tech sector are the innovation clusters of Silicon Valley in the USA and the Scandinavian cluster of mobile phones, while Food Valley NL is a well-known cluster in the agrifood sector in the Netherlands. Since clear sector differences have been identified in innovation (Malerba, 2004) and some authors link these differences to the technology level (based on the level of R&D input) of the different sectors (e.g. Pavitt, 1984), three clusters with different technology levels are compared: in the high-tech, the medium-to-high-tech (green biotech) and the low-to-medium-tech (agrifood) sector. So-called cluster (coordinating) organizations support the cluster member companies (Omta and Fortuin, 2013, Klerkx and Leeuwis, 2009, Batterink, 2009, Klerkx and Leeuwis, 2008, van Lente et al., 2003). Research question 1 consequently asks:

Research question 1: Are there differences to be observed in cluster organization support in different clusters (electronics, green biotech and agrifood)(1a), and if so what can be learned from these differences (1b)?

Data were collected using 33 semi-structured interviews with different stakeholders from three innovation clusters in the Netherlands to answer research question 1. The cluster organizations supporting the electronics, green biotech and agrifood companies differed in their founding mode and way of financing of the cluster organization. Further there are differences in sectorial focus and differences in tech-level of the companies that the cluster organizations support. The results suggest that we should not relate the findings too closely to the tech-level of the companies in the clusters. In line with the findings of other authors (e.g. Asheim and Coenen, 2005, Kirner et al., 2009) the companies in the different clusters show a high heterogeneity in terms of tech-level, which makes an answer related to the general tech-level of the cluster less reliable. Instead, the findings suggest that the founding and financing mode of the cluster organization and the sectorial focus are more important in explaining the differences found.

Concerning the cluster organization's functions a number of similarities were found. For all three clusters it can be concluded that the *network formation support function*, that means *facilitating linkages between relevant actors* by *scanning, scoping, filtering, and matchmaking of possible cooperation partners* (Klerkx and Leeuwis, 2009) is considered to be very important. Cluster organizations provide this support by organizing seminars, workshops and cluster member meetings. In the electronics and biotech cluster further partnership experience is created by conducting the cluster organization activities as a virtual organization sourcing from member companies' staff. Sector independence can be found concerning the *innovation process support* function, e.g. by promoting the region as an attractive living and working area for highly qualified employees, which supports the companies in accessing the highly qualified staff needed to conduct the innovation process. The results also show a number of clear differences among the investigated clusters. Only in the agrifood cluster was there a clear need for *internationalization support* for SMEs to reach foreign markets, while only in the green biotech cluster the *demand articulation* was focused on the region where the cluster is based, which stands in contrast to the highly international orientation of the member companies. And only in the electronics cluster does the cluster organization play a key role in developing technology and market road maps, indicating possible future trends and technology changes to direct the innovation process of the member companies, to keep a leading position as a cluster. This powerful tool, developed to align the member companies' innovation processes at the sector level, clearly impacted the *demand articulation* and *network formation support functions*, and could therefore also be a useful tool for the green biotech and the agrifood cluster.

The two cluster organizations that were founded and mainly financed by the cluster member companies conducted the cluster functions sourcing from member companies' staff. This way the network formation support function could be easily implemented, since staff members from the member companies partnered with the cluster organization's staff as a virtual organization. In these clusters, a clear focus on demand articulation was found, both on the regional and on the national level. In the cluster where the public role, in terms of the cluster organization's initiation and financing, dominated, more focus was put on network formation support, with matchmaking taking up a prominent role. The internationalization support function was only found in the agrifood, and was clearly appreciated by the SMEs. In the other two clusters the members did not express a need for internationalization support. From the interviews it could be concluded that the SMEs in the electronics and green biotech cluster were already, in clear contrast to most SMEs in the agrifood cluster, very internationally oriented in terms of sales and innovation cooperation, explaining the lower need.

From the differences found, it can be learned that sourcing staff hours from member companies of the cluster organization's activities creates a higher identification with the cluster overall and a greater efficiency in executing cluster organization's functions. At the same time, the financing mode of the cluster organization (more privately financed versus more publicly financed) puts a different filter on the activities.

For the cluster organizations that are mainly financed by member companies' contributions, the findings indicate that one needs to stay alert in order not to lose SME interest in cluster membership, due to the overruling influence of the larger member companies. This is also of interest to the larger companies, that indicated the advantages of interconnections with cluster member SMEs. In the more publicly financed cluster, the cluster organization is advised to conduct more cluster activities using member companies' staff. That way it is easier to keep in touch, since a strong feedback loop is created using mixed teams of cluster organization and member company staff. For the companies that engage in a cluster it is recommended to actively participate in network activities. Concerning the staff hour resource restrictions of SMEs, SMEs could as a subgroup make sure that there is always at least one SME representative involved in the activities to keep a balance of interests. One might also consider publicly financed compensation of the SME representatives engaging in network activities, instead of hiring additional cluster organization staff. The findings of this study suggest that this could create stronger cluster identification.

Summarizing the findings of Chapter 2, one may suggest that a comparison of clusters can indeed lead to meaningful results and to the identification of tools used in one cluster that are potentially useful for other clusters. This applies especially to the *technology and market road mapping tool* used in the electronics cluster to align the company and the cluster functions. However this chapter also shows the limitations of using the *tech-level* or the *regional innovation system* (RIS) typology (Section 2.2.2), as described by Asheim and Coenen (2005), to distinguish between the clusters. To assess a cluster as comprising one tech-level failed, especially in the agrifood sector, where the member companies showed clearly different tech-levels. The RIS typology postulates integration of knowledge institutions in the cluster member companies' support, creating spin off companies (ex-ante), or providing ex-post support to existing companies. Especially in the green biotech cluster, however, seed companies grew into a new research field (green biotech) and received ex-post support, a case that is not provided for in the RIS typology.

Research question 2

In Chapter 3 and 4 the focus moves to innovation management at the strategic alliance level. In the present book (Section 1.2.2), an innovation alliance is defined as a cooperative agreement between two or more parties with the aim of innovating, based on ongoing collaborative exchange, in order to develop new knowledge, products and processes, while maintaining their corporate identities *(Hamel, 1991, Gulati, 1998, De Man and Duysters, 2005)*. A literature review by Comi and Eppler (2009) highlights a lack of research on alliance management. The objective of Chapter 3 is to fill up this gap by studying the alliance collaboration process to explore the characteristics of both successful and less successful innovation alliances among biotech SMEs.

Research question 2: Which characteristics are positively and/or negatively related to the performance of innovation alliances of biotech SMEs?

Chapter 3 provides an attempt to show the interaction effects among the alliance performance factors in a structural equation model. By limiting the modeling attempt to a well-researched, highly specific type, the innovation alliances of biotech SMEs, the foundations for an alliance collaboration model have been established.

Chapter 3 analyzes the different stages in the innovation alliance collaboration process to identify the key factors influencing alliance performance. To answer Research question 2, the conceptual model presented in Figure 3.1 was tested employing Partial Least Squares (PLS), using a sample of 40 alliances by 18 Dutch biotech SMEs. The main hypothesis: *Innovation alliances that show a higher level of complementarity and overcome cognitive distance with intense knowledge resources exchange lead to the creation of synergy and ultimately to a higher level of innovation performance,* holds true as the significant path coefficients in the PLS model indicate. The central role of knowledge resources exchange becomes visible throughout the model. The positive path coefficient from resource complementarity leading to knowledge resources exchange and from knowledge resources exchange directly to exploration performance underscores that human resource exchange is the primary way of exchanging and converting both explicit and tacit knowledge in an innovation alliance.

Further, the governance mechanisms of relational trust, technology mapping and task division were positively related to alliance performance of biotech SMEs. Negative relations were found related to the use of technology mapping. Technology mapping is only used in the case of low resource complementarity, a low level of relational trust and/or a low level of knowledge resources exchange. However, it is suggested by the author that also in cases of high resource complementarity (implicating a large cognitive distance between the alliance partners) the collaboration might benefit from technology mapping as a communication tool. A higher level of complementary resources, extensive knowledge exchange, the use of technology mapping and task division within an alliance are directly and positively related to a higher performance of innovation alliances of biotech SMEs. Further there are a number of indirect positive and negative relations worth mentioning to complete the picture of which characteristics relate to alliance performance. There are different paths leading from alliance potential to alliance performance (Figure 3.2).

In cases where the alliance was given a higher importance by the biotech SME, in cases of higher resource complementarity between the alliance partners and in cases of high relational trust, an indirect positive relation is found to the alliance performance due to an increased knowledge resources exchange.

Research question 3
Chapter 4 takes the findings of the alliance collaboration model developed in Chapter 3 and tests them in a European, cross sectional, quantitative study of alliances to highlight the role of structural and relational governance in the alliance collaboration process. Based on the findings in Chapter 3 and by extending the literature study, the collaboration model in Chapter 4 was designed to answer the more specific performance related research question:

Research question 3: What is the impact of the use of different structural and relational governance mechanisms on the performance of innovation alliances?

Chapter 4 aims to extend the work on the use of structural and relational governance in case of different levels of interdependency among innovation alliance partners. Structural governance mechanisms refer to formal agreements that are often written down in contracts, whereas relational governance mechanisms are built on trust, using informal norms and rules. In innovation literature relatively much attention has been spent on relational governance, which is expected to offer the flexibility needed for innovation, whereas the role of structural governance is underexposed. The discussion of the alliance collaboration process from the resource based view (RBV) and knowledge based view (KBV), while linking it to the discussion of reciprocal interdependence, leads to nine hypotheses (Section 4.2.2 – 4.2.5). Based on these hypotheses, a conceptual model was formed of the main constructs divided over the different phases of the innovation alliance process.

The model was empirically tested using PLS (Figure 4.2), employing a cross-sectorial dataset of 94 innovation alliances in the Netherlands, Belgium, Germany, Austria and Switzerland. The results show that structural and relational governance clearly complement each other. While upfront agreements provide a platform for good coordination in the alliance execution phase, relational governance makes the communication among alliance partners easier and leads to a higher level of knowledge exchange, ultimately leading to better innovation outcomes and alliance satisfaction. However, no direct positive relationship between structural and relational governance was found, and the frequency of communication was not found to be positively related to relational trust, which leaves Hypotheses 3 and 4a unconfirmed (Table 4.5).

The successful resource exchange within an alliance could be identified as a necessary precondition for increased alliance performance. Structural governance mechanisms, such as a clear task division within the alliance, and the input related agreements dealing with the interdependency in the alliance can improve the confidence that the partner will not act opportunistically, thus enhancing resource exchange, which has a positive impact on the alliance performance. Output related agreements lessen the need to renegotiate and therefore improve the communication efficiency within the alliance. Risk related agreements were used more in case the alliance was given a higher importance status. The relational governance mechanisms also positively influence the resource exchange and in contrast to the structural governance mechanisms are directly and positively related to alliance performance. Relational governance stimulates knowledge exchange directly, but also via the enhanced ease of communication. The positive relationship of both types of governance mechanisms to resource exchange and alliance performance clearly shows the complementarity between structural and relational governance mechanisms.

Research question 4
Chapter 5 takes a closer look at the impact of the complexity of the innovation process in an inter-organizational setting. This is investigated in a Dutch public private research partnership (PPRP) in the plant breeding sector, the Centre for BioSystems Genomics (CBSG). PPRPs aim at combining

"the resources of government with those of private agents (business or not-for-profit bodies) in order to deliver societal goals" (Skelcher, 2005). This leads to the following research question 4.

Research question 4: Does the technical complexity of the innovation process, as reflected by the length of the product generation life cycle (PGLC), influence the knowledge valorization process in a public private research partnership (PPRP) in the plant breeding sector (4a), and if so, in what way (4b)?

CBSG can be regarded as a combination of single innovation alliances that form one innovation network, including four universities, two research institutes and 15 companies. To answer research question 4, data were collected from CBSG participants. In total 15 companies participated in the study, seven companies with a PGLC of 5 to 6 years, active in the tomato sector, and eight potato companies with a PGLC of 25 years or more. This difference is based on the breeding complexities from a diploid genome (tomatoes) versus a tetraploid genome (potatoes). The results show a clear relation between CBSG's valorization support activities and the level of knowledge valorization by the participants, although the preferred type of support activities differs between the potato and tomato companies. Firms with a long PGLC, having a higher complexity of the R&D process, require more basic research support and extra communication tools that help to bridge gaps caused by the long duration of the development process. Companies with short PGLCs, being challenged to keep development time of new products as short as possible in order not to miss out on market opportunities, value the PPRP most for the networking possibilities and as provider of the latest technological developments.

The technical complexity of the breeding innovation is found to influence the knowledge valorization process. With the increased technical complexity of the breeding innovation also the product generation life cycle (PGLC) is found to increase, which impacts the knowledge valorization process. Within the public private partnership (PPRP) the length of the PGLC has a mediating effect on the relation between the knowledge valorization support provided within the PPRP and the knowledge valorization performance of the companies participating in the PPRP. Depending on the technical complexity of the breeding innovation and therefore the PGLC length, companies facing a lower technical complexity and working in short PGLCs benefit more from the interconnectedness within the PPRP that allows them to engage in precompetitive fundamental research projects, but also keeps them updated on the latest developments. Companies facing a higher technical complexity in the breeding process and working in sectors with long PGLCs, benefit from the publicly generated knowledge to challenge the technical complex developments and from communication tools, such as technology monitoring and road mapping, to manage the complexity of the long term R&D process.

6.2 Main conclusions

A rich assortment of books, scientific articles and publications has been devoted to investigating the link between external sourcing and innovation success. The literature typically refers to innovation alliances and innovation networks, while innovation alliances are frequently embedded within bigger innovation networks. This book focuses on the alignment of governance mechanisms at innovation network and innovation alliance level. When linking the research findings at the network to the alliance level, a number of conclusions can be drawn.

It can be concluded that cluster organizations play an important role in creating favorable conditions for innovation in inter-organizational settings. Their support, ranging from organizing conferences and meetings in which potential alliance partners get to know each other, to helping to find co-financing by public parties (e.g. EU or national), can positively influence alliance formation, as well as ongoing or future alliance cooperation. If a cluster organization coordinates and helps to develop technology and market road maps, such as in the electronics cluster, this can even help to determine the subject choice for future alliance formations within a network.

Cluster organizations can even help to create relational trust between members of the network that can substitute for earlier alliance experience with a partner. However, this depends on the way the cluster organization's functions are conducted. In cases where the cluster organization's functions are conducted by a virtual organization, based on staff hour contributions of the member companies, then the member companies get to know each other, generating relational trust that can be important, in the case that cluster members decide to engage together in an innovation alliance. Active cluster engagement further allows for governance mechanisms in the form of gentlemen agreements when it comes to staff migration within the cluster. This can also enhance the willingness of companies to engage in alliances within the cluster, since they feel more secure about their intellectual property (IP) embedded in their human capital (e.g. secret recipes in agrifood).

Pre-alliance experience with an alliance partner allows for relational governance mechanisms to be used right from the start of the alliance collaboration, which might lead to speeding up the innovation process, as can be concluded from the positive influence that relational governance mechanisms and improved relational trust were found to have on the knowledge resources exchange in Chapter 3 and 4. However, the relational governance mechanisms based on earlier experiences and/or through cluster activities cannot substitute for the clarity and alliance coordination improvements achieved through structural agreements made at the beginning of the innovation alliance collaboration, as was shown in Chapter 4.

Similar positive effects from the network level on alliance formation were found in the PPRP studied in Chapter 5. Besides looking at innovation alliances, also the impact of the PPRP innovation network as a whole (members: 15 companies, 7 knowledge institutions and 2 industrial associations) has to be considered. Consequently, also a number of support activities provided within this PPRP by the public partner are found, that are rather similar to the cluster organization support activities in Chapter 2.

6.2.1 Scientific contributions

The findings in Chapter 2 contribute to the research on cluster organization functions (Omta and Fortuin, 2013, Klerkx and Leeuwis, 2009, Batterink, 2009, Klerkx and Leeuwis, 2008, van Lente et al., 2003) by studying how cluster organizations conduct their support functions in three clusters that differ significantly in founding and financing mode and sector focus, which contributes to the research need stated by a number of authors (Batterink et al., 2010, Boon et al., 2008, Boon et al., 2011, Sapsed et al., 2007, Winch and Courtney, 2007) to identify how intermediary organizations such as cluster organizations function under different circumstances. The findings also point in the direction of rethinking the OECD classification that oversimplifies by connecting industries to one technology level, and confirms the findings of Kirner et al. (2009) who find a mix of different tech-level companies per industry.

The innovation alliance collaboration models developed in Chapter 3 and 4 merge the insights gained from the resource/knowledge based view and governance perspective. They extend the basic alliance formation model developed by Chiesa and Manzini (1998) by implementing the findings concerning the impact of cognitive distance (Nooteboom et al., 2007) as well as the impact of interdependency (Thompson, 1967).

Chapter 3 especially contributes to the research need stated by Khilji et al. (2006) by providing additional insights into how biotech SME innovation alliances can be successfully managed. The specific findings concerning the collaboration success factors of biotech SME innovation alliances add to the findings of other authors that have studied the impact of alliance duration, environmental uncertainty (Pangarkar, 2003), the alliance portfolio (Baum and Silverman, 2004, George et al., 2001) or network composition and dynamics (Gay and Dousset, 2005) on alliance performance. Further, the research in Chapter 3 agrees with other alliance collaboration studies concerning knowledge management (e.g. Nooteboom et al., 2007, Standing et al., 2008), alliance capabilities (Heimeriks and Duysters, 2007) and governance modes (Phene and Tallman, 2012).

The findings in Chapter 4 contribute to the controversy between authors suggesting a substitution possibility between structural and relational governance mechanisms in inter-organizational collaborations on the one hand (Dyer and Singh, 1998, Gulati, 1995, Larson, 1992, Adler, 2001), and authors that challenge the substitutability assumption on the other (e.g. Poppo and Zenger, 2002, Zheng et al., 2008, Gulati, 2007, Grandori, 2001). The findings of Chapter 4 suggest a complementarity relationship between structural and relational governance mechanisms (see also Poppo and Zenger, 2002, Tepic et al., 2011). The positive impact of structural and relational governance mechanisms on knowledge exchange in innovation alliances accords with the findings of Dhanarag and Parkhe (2006) who also reported a positive effect of structural agreements on knowledge mobility. Further, a positive effect of lowering the alliance interdependence due to task division was shown. Chapter 4 therefore confirms a number of other empirical studies testing the interdependence effect on the alliance performance (e.g. Jia et al., 2007, Wong et al., 2005, Krishnan et al., 2006, Sambasivan et al., 2011, Das and Teng, 2003).

Chapter 5 contributes to the research on PPRPs. A number of authors (Fontana and Geuna, 2005, Santoro and Chakrabarti, 2002, Widdus, 2001) have related the effectiveness of knowledge valorization in PPRPs to company parameters, such as company size and the industry the company is located in. In Chapter 5 the complexity of the innovation process itself has been shown to be another parameter that should be taken into account when studying the knowledge valorization in PPRPs. It extends the research conducted by Fortuin (2007) in a cross industry study, that highlighted the importance of the alignment of the innovation to the business strategy related to the PGLC.

6.2.2 Limitations and directions for further research

The findings presented in this thesis should be regarded with some caution. Since the findings in Chapter 2 are based on three clusters only, further research based on a larger number of clusters will be needed. The collaboration models developed in Chapter 3 and 4 also show a number of limitations. While Chapter 3 focuses on the alliance collaborations of one specific company group (the Dutch biotech SMEs) the study in Chapter 4 displays the alliance collaboration process for different respondent groups. It would be interesting to increase the number of respondents per group in order to be able to obtain more in-depth insights into the possible differences at group level (e.g. SMEs versus large companies, green versus pharma biotech). Secondly, the data that were used to empirically test our hypotheses were collected at one ‘moment-in-time’. This creates problems in positioning certain alliance execution constructs. The task division, for example, in both PLS models (Figure 3.2 in Chapter 3 and in Figure 4.2 in Chapter 4) is positively connected to knowledge resources exchange. Theoretically it can be argued that task division leads to knowledge resources exchange but also the other way around. Both arrow directions for the PLS model are thinkable and the research in this thesis does not answer which position in the model should be preferred for the task division, before or after knowledge resources exchange. It shows however the limitations of the PLS model in displaying a collaboration process, where one process does not simply follow another, but they rather alternate or even are executed simultaneously (the same applies to the two constructs’ frequency of communication which is positively related to relational trust in Figure 4.2). Therefore, to display such a process in a simple flow chart with arrows pointing only in one direction oversimplifies the complexity of the alliance collaboration process due to reciprocal interdependence. Therefore the criticism by (Kline and Rosenberg, 1986) that *models* *that depict innovation as a smooth, well-behaved linear process badly misspecify the nature and direction of the causal factors at work* as *innovation is complex, uncertain, somewhat disorderly, and subject to changes of many sorts,* also applies to the alliance collaboration models in this book. To better uncover the causality directions in the model, it would be interesting to use longitudinal data to follow the different alliance collaboration phases. Thirdly, in the present study no clear distinction could be made between contractual and non-contractual agreements. It is suggested for further research to capture both dimensions to see how they relate to relational governance in the alliance collaboration. Further, a number of questions were only assessed with regard to the most important partner. For alliances with more than two partners this ignores the possible influence of the other partners.

The alliance collaboration models in Chapter 3 and 4 also show limitations concerning the alliance output focus, or alliance goal, which has been kept rather broad. E.g. Enzing (2009) *found that the management of the innovation process of new products differs significantly from that of improved products*. She found new products to demand a more organized and structured process, compared to the development of improved products. In combination with our findings concerning the interrelations between structural and relational governance, this suggests that also the innovation alliance collaboration process could differ depending on whether the alliance partners start an alliance with the goal of improving an existing product or try to develop an entirely new product. Future studies should aim at catching the differences between these two types of innovation alliances.

A number of authors (Fontana and Geuna, 2005, Santoro and Chakrabarti, 2002, Widdus, 2001) relate the effectiveness of knowledge valorization in public private research partnerships (PPRPs) to company parameters, such as company size and the industry the company belongs to. In Chapter 5 the complexity of the innovation process itself, as indicated by the product generation life cycle (PGLC), has been shown to be another parameter that should be taken into account to efficiently conduct the knowledge valorization in a PPRP. It extends therefore the research conducted by Fortuin (2007) in a cross industry study, that highlighted the alignment needs of innovation strategies related to the alliance complexity resulting in PGLC differences. However, as the findings in Chapter 5 are based on only 15 companies they cannot be generalized. Further, the influence of the alliance complexity is only shown concerning the support activities provided in a PPRP in the breeding sector. It would therefore be recommended to study the influence of the innovation complexity in a structural equation model, like the ones presented in Chapter 3 and 4, using innovation complexity as a construct influencing the alliance execution phase.

6.3 Recommendations

The aim of this book is to increase our understanding of the impact of the governance choices on the innovation performance of innovation alliances and innovation networks. This book can be used by companies to improve the management of their inter-organizational innovation projects. Cluster coordinators can use it to improve their member support, and to enhance cluster performance. Policy-makers can increase their insight into the way in which inter-organizational partnerships can be organized and managed and how they can best be supported on the network level.

6.3.1 Innovation managers

The findings of this thesis firmly suggest that for innovation alliances to be successful, companies should start by looking for partners that have complementary skills and resources, companies that have something to offer each other. Our finding that a large cognitive distance, next to providing a bigger alliance potential, also proved to be a bigger challenge to the knowledge exchange and synergy creation deserves special management attention. If there is a too limited communication basis for the alliance partners due to a large cognitive distance, the alliance is likely to end in failure. In such a case, experts who are familiar with both research and/or business fields might be used to bridge the knowledge gap. To make efficient use of complementary resources, a clear division of tasks between the alliance partners is needed. If companies do too many things together, this might create too large interdependencies that will be very difficult to coordinate in the alliance execution phase.

Managers should be aware of the positive, coordination enhancing effect of structural upfront agreements and of the fact that relational governance can only partly substitute for such agreements. Even when starting with an alliance partner where there exists relational trust due to previous experience, structural governance mechanisms proved to be of great use in improving alliance coordination. As Omta and Van Rossum (1999) indicate, the partners should strive for clear accountability through performance measures. A joint steering committee with enough authority should meet periodically to review goals and progress against schedules. This is very important, because it creates a feeling of urgency. In the home-companies of the partners there are always activities which seem more urgent than a collaborative project with a far-away partner. Stringent deadlines help to avoid arrears and overrun of budget.

Technology mapping can prevent several risks from striking at the same time. First, it helps to avoid misunderstandings between the alliance partners about the progress of the alliance work, as there is a proper documentation in place of what has been achieved so far. Second, it lessens the risks of missing any pieces in the innovation process, as it makes missing parts become more visible. Further, looking at a summary of the alliance collaboration's intermediary results can inspire and help to determine the future direction of the alliance collaboration and the choice of complementary governance mechanisms.

Misunderstandings can always occur, even if the partners know each other very well. The easiest way to avoid misunderstandings is to communicate at high frequency via telephone or face-to-face contacts, which provide direct feedback and clarification of misperceptions. The benefits of frequent communication in building up mutual understanding and in checking up on the progress of the collaboration saves time and costs by making far more costly adjustments later on in the collaboration unnecessary. To communicate frequently, sending all relevant memos and team reports to each other clearly helps in creating a climate of trust. The risk of losing intellectual property, e.g. secret recipes in case of food SMEs, sets limits to human resources exchange, unless structural and relational governance can provide a safe alliance collaboration environment for doing so.

6.3.2 Cluster coordinators

Recommendations to cluster organization coordinators concern the organization of the network. To keep the cluster members interested in participating in a cluster its goals should be formulated as clearly as possible and shared by the cluster members, and results based on the goals should be achievable in manageable time frames. A goal like 'improving the innovativeness of the cluster about 50% within the next 20 years' gets no company member interested and is not concrete enough to be shared. The findings in the electronics cluster show that a cluster organization should engage in collecting research needs based on market and technology trends that allow the creation of a technology and market roadmap that member companies can use to see which precompetitive research activities they can conduct together, e.g. in a strategic alliance or a PPRP.

Another interesting idea came from the electronics and green biotech cluster that based their activities if possible on sourcing staff hours from diverse member companies. This creates a partnership experience, potentially creating relational trust that can be used in future alliances between these member companies. Cluster member companies should get to know each other. Business online networks like Linked-in or Xing can help in creating virtual groups and give a forum to posting information and showing the receiver at the same time.

As Omta and Fortuin (2013) showed, the most important function of the cluster organization is the network formation support function. Concerning the organization of matchmaking events the findings of this thesis show that cluster members expect the cluster organization to carefully select attendants to these meetings. As part of the innovation process support activities, they can organize special workshops for SMEs on how to behave successfully in an innovation alliance. In such workshops open innovation support tools, such as contractual arrangements and technology and IP mapping, can be presented. Enhanced use of these collaborative support tools may also reduce the fear that many biotech SMEs have of stepping into an alliance, because a lack of clarity regarding the future ownership of expected results often destroys the necessary compliance level needed to bring the collaboration successfully to a close.

6.3.3 Policy makers

Policy makers are recommended to support innovation alliances by providing an infrastructure in which innovation alliances can flourish. Innovating in different sectors frequently happens at different velocities. The findings of the present thesis show that this implies different support requirements from the public innovation partner. Consequently, policy makers should take into account the innovation complexity, which is reflected in the length of the product generation life cycle in the design of the support activities provided, e.g. in public private partnerships. One way to do this is by stimulating the formation of cluster organizations that can function as innovation brokers that provide network formation, demand articulation, internationalization and innovation process-support to their member companies (also Omta and Fortuin (2013)); such organizations could also act as go-betweens among alliance partners (Nooteboom, 1999b, 1999a).

Concerning SMEs engaging in alliances, their fear of losing unprotected IP when engaging in alliances with more powerful organizations, deserves much more policy attention. If SMEs could feel more secure concerning their intellectual property (IP) this would stimulate additional alliance formations and improve alliance collaboration behavior in terms of knowledge exchange, in alliance with non-symmetric power distribution between the partners.

At first glance the recommendation to further increase the number of innovation support organizations at regional, national and international levels might be regarded as superfluous, considering the number of innovation support organizations that already exist. However, the study shows that many companies are members of more than one network to cover their innovation needs. In order to increase the network engagement efficiency, policy makers could provide a network support assessment tool to SMEs to allow them to get a clear account of what kind of support they could get from which network. An example of such an evidence based toolbox directed to assess the innovation support activities and the level of innovation support at EU level is NetGrow, the EU project that also formed the foundation of the research on which the findings of this book are based, including food SMEs, universities and cluster support organizations from nine different European countries.

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Summary

To remain competitive in a world of global competition a company has to adapt to changing situations at an increasing speed. This often requires more resources than the company can provide. By combining the resources and core competencies of different companies in an 'open innovation' project the race might be won. Therefore *the capability of building and maintaining inter-organizational network relationships, such as joint ventures, license agreements, supplier customer partnerships and strategic alliances is increasingly viewed as key to sustained competitive advantage* (Omta and Van Rossum, 1999). However, the list of possible inter-organizational collaboration problems is long. Critical issues that play a role in an inter-organizational cooperation range from: *Which company is contributing what, how high are the coordination costs, is the exchange of knowledge symmetric enough* (problem of outlearning the partner, Hamel, 1991*); and which company is benefiting most from the results* (Farr and Fischer, 1992*)?* The conclusion may be derived that the open innovation business model is not a self-evident choice. Instead the decision boils down to the question: *Do the additional benefits from using an open innovation model exceed the additional costs?* Based on the number of partners involved and the interdependencies between the partners, a balance of contributions and results should be aimed for. To achieve this balance, different governance mechanisms can be employed. In contrast to the occurrence of inter-organizational collaboration problems, the governance mechanisms for controlling them and especially the interplay between different governance mechanisms are far less researched. This leads to the main objective of this book.

Main objective: To analyze different governance mechanisms that can be used by stakeholders, such as alliance managers, cluster coordinators and policy makers, to improve innovation alliance and network performance. The findings of this thesis aim at deriving recommendations to be applied at the international, national and regional level as well as at the innovation alliance level.

Several theories have been employed to shed light on the interplay between innovation management on the level of the innovation network (cluster) and the innovation alliance. In Chapter 2, the innovation system theory has been used to focus on the support of clusters by cluster organizations. In Chapter 3, the resource/knowledge based view helped to specify key success factors of innovation alliances, while in Chapter 4 the governance perspective together with the interdependence theory allowed new insights concerning the employment of different innovation alliance governance mechanisms and how these affect the innovation alliance process. Finally, in Chapter 5, within the Dutch public private research partnership (PPRP) in plant breeding, the Center for BioSystems Genomics (CBSG), the impact of innovation complexity, as reflected in the length of the product generation life cycle (PGLC), on the requested innovation support provided by the public partner was studied.

Chapter 2 takes a first step in answering the main research question: how to address the organizational challenges stemming from innovation in inter-organizational settings, by focusing on the network (or cluster) level. Since clear sector differences have been identified in innovation (Malerba, 2004) and some authors link these differences to the technology level (based on the level of R&D input) of the different sectors (e.g. Pavitt, 1984), three clusters with different technology levels are compared: clusters in the high-tech (electronics), the medium-to-high-tech (green biotech) and the low-to-medium-tech (agrifood) sector. So-called cluster (coordinating) organizations support the cluster member companies (Omta and Fortuin, 2013, Klerkx and Leeuwis, 2009, Batterink, 2009, Klerkx and Leeuwis, 2008, van Lente et al., 2003). Research question 1 consequently asks:

Research question 1: What are the similarities and differences in cluster organization support in clusters in sectors of different technology level (electronics, green biotech and agrifood,1a), and what can be learned from the differences (1b)?

Data were collected using 33 semi-structured interviews with the cluster directors, regional politicians, knowledge institutions and the innovation managers of large companies and SMEs from the three innovation clusters (see Table 2.1). Concerning the cluster organization's functions a number of similarities were found. For all three clusters it can be concluded that the *network formation support function*, that means *facilitating linkages between relevant actors* by *scanning, scoping, filtering, and matchmaking of possible cooperation partners* (Klerkx and Leeuwis, 2009) is considered to be very important. Cluster organizations provide this support by organizing seminars, workshops and cluster member meetings. In the electronics and biotech cluster further partnership experience is created by conducting the cluster organization activities as a virtual organization sourcing from member companies' staff. Sector independence can further be found concerning the *innovation process support* function, e.g. by promoting the region as an attractive living and working area for highly qualified employees, which supports the companies in accessing the highly qualified staff needed to conduct the innovation process. The results also show a number of clear differences among the investigated clusters. Only in the agrifood cluster there was a clear need for *internationalization support* for SMEs to reach foreign markets, while only in the green biotech cluster the *demand articulation* was focused on the region where the cluster is based, which stands in contrast to the highly international orientation of the member companies. And only in the electronics cluster does the cluster organization play a key role in developing technology and market road maps, indicating possible future trends and technology changes to direct the innovation process of the member companies, to keep a leading position as a cluster as a whole. This powerful tool, developed to align the member companies' innovation processes at the sector level, clearly impacted the *demand articulation* and *network formation support functions*, and could therefore also be a useful tool for the green biotech and the agrifood cluster.

In Chapter 3 and 4 the focus moves to innovation management at the alliance level. In Section 1.2.2 an innovation alliance is defined as a cooperative agreement between two or more parties with the aim of innovating, based on ongoing collaborative exchange, in order to develop new knowledge, products and processes, while maintaining their corporate identities *(Hamel, 1991, Gulati, 1998, De Man and Duysters, 2005)*. A literature review by Comi and Eppler (2009) highlights a lack of research on alliance management. The objective of Chapter 3 is to fill up this gap by studying the alliance collaboration process to explore the characteristics of both successful and less successful innovation alliances among biotech SMEs.

Research question 2: Which characteristics are positively and/or negatively related to the performance of innovation alliances of biotech SMEs?

Chapter 3 provides the first attempt to show the interaction effects among the alliance performance factors in a structural equation model. By limiting the modeling attempt to a well-researched, highly specific type, the innovation alliances of biotech SMEs, the foundations for an alliance collaboration model have been established. Chapter 3 analyzes the different stages in the innovation alliance collaboration process to identify the key factors influencing alliance performance. To answer Research question 2, the conceptual model presented in Figure 3.1 was tested employing Partial Least Squares (PLS), using a sample of 40 alliances by 18 Dutch biotech SMEs. The main hypothesis: *Innovation alliances that show a higher level of complementarity and overcome cognitive distance with intense knowledge resources exchange lead to the creation of synergy and ultimately to a higher level of innovation performance,* holds true as the significant path coefficients in the PLS model indicate. The central role of knowledge resources exchange becomes visible throughout the model. The positive path coefficients from resource complementarity, the importance of the alliance, the relational trust among the partners and a clear task division all leading to knowledge resources exchange and from knowledge resources exchange directly to exploration performance underscores that human resource exchange is the primary way of exchanging and converting both explicit and tacit knowledge in an innovation alliance. The negative path coefficients between relational trust, knowledge exchange and resource complementarity with technology mapping may indicate that in cases where the partners do not (yet) trust each other, e.g. because they have no previous experience, they choose to come to a clear demarcation of technology fields (e.g. by patent search). The result that technology mapping is positivly related to the exploitation performance seems to indicate that this instrument is especially used if an innovation alliance is mainly directed on the short term development of a product or proces.

Chapter 4 takes the findings of the alliance collaboration model developed in Chapter 3 and tests them in a European, cross sectional, quantitative study of 94 alliances to highlight the role of structural and relational governance in the alliance collaboration process. Based on the findings in Chapter 3 and by extending the literature study, the collaboration model in Chapter 4 was designed to answer the more specific performance related research question:

Research question 3: What is the impact of the use of different structural and relational governance mechanisms on the performance of innovation alliances?

Chapter 4 aims to extend the work on the use of structural and relational governance among innovation alliance partners. Where structural governance mechanisms refer to the division of tasks within the alliance and to upfront contractual and non-contractual input, output and risk related agreements, relational governance mechanisms refer to trust, using informal norms and rules for coordination purposes. In innovation literature much attention has been spend on relational governance, which is expected to offer more flexibility needed for innovation than the as rigid perceived regulations in structural governance. However, it is argued by the author that the essential role of structural governance as a solid basis for creating trust, especially in alliances in which the partners do not yet know each other, is clearly underexposed in management literature. To fill up this gap, a model conceptualizing the innovation alliance from inception to performance was tested using Partial Least Squares, employing a cross-sectional dataset of 94 innovation alliances in the Netherlands, Belgium, Germany, Austria and Switzerland. The results in figure 4.2 indeed show the essential role of structural agreements to create a platform for trust on which relational governance can strive, while a clear task division can help to reduce the complexity of the inter-organizational innovation process, by reducing the interdependency of the partners. Both structural mechanisms ease the communication among the alliance partners, leading to a higher level of knowledge exchange, and ultimately leading to better alliance performance.

Related to the findings in Chapter 3 it shows that resource complementarity, combined with a clear task division, leads to smootened tacit knowledge exchange and to easier exchange of physical resources. Risk related agreements seems to be especially made in alliances which are regarded as very important by the company. The negative relation with task division seems to indicate that these are premarily made if it is not possible to make a clear division of tasks because of a too low level of competence complementarity. Just like in Chapter 3, the output related agreements seems to be prevalent in alliances in which products and processes are developed that are close to the market, so that extensive communication seems less relevant.

Chapter 5 takes a closer look at the impact of the complexity of the innovation process in an inter-organizational setting. This is investigated in a Dutch public private research partnership (PPRP) in the plant breeding sector, the Centre for BioSystems Genomics (CBSG). PPRPs aim at combining *"the resources of government with those of private agents (business or not-for-profit bodies) in order to deliver societal goals"* (Skelcher, 2005). This leads to the following research question 4.

Research question 4: Does the technical complexity of the innovation process, as reflected by the length of the product generation life cycle (PGLC), influence the knowledge valorization process in a public private research partnership (PPRP) in the plant breeding sector (4a), and if so, in what way (4b)?

CBSG can be regarded as a combination of a number of innovation alliances that form one innovation network, including four universities, two research institutes and 15 companies. To answer research question 4, data were collected from all 15 companies that participate in CBSG participants, 7 companies are active in the tomato sector with an average PGLC of 5 to 6 years and 8 companies are active in the potato sector with an average PGLC of 25 years or more. This difference is especially based on the breeding complexities stemming from a diploid genome (tomatoes) versus a tetraploid genome (potatoes). The technical complexity of the breeding innovation is found to influence the knowledge valorization process. The results show a clear relation with the kind of valorization support of CBSG that these companies need and the length of the PGLC. Firms from the potato sector require more basic research support and extra communication tools, like technology monitoring and road mapping, to manage the complex and long term innovation process. Tomato companies with shorter PGLCs, being challenged to keep development time of new products as short as possible in order not to miss out on market opportunities, value CBSG most for the networking possibilities and as provider of the latest technical apparatus and methodologies.

In Chapter 6, the managerial implications of the present thesis have been translated into a number of recommendations to innovation alliance managers, cluster organization coordinators and policy makers.

Samenvatting

Om concurrerend te blijven in dit tijdperk van globalisering moeten bedrijven in staat zijn om zich snel aan te passen aan veranderende omstandigheden. Dit vereist vaak meer middelen en andere vaardigheden dan een bedrijf tot zijn beschikking heeft. Door de middelen en de vaardigheden van meerdere bedrijven te combineren in zogenaamde ‘open innovatie‘ projecten zou de race gewonnen kunnen worden. Daarom wordt het vermogen om netwerken en netwerkrelaties, zoals joint-ventures, licentieovereenkomsten, partnerships van leveranciers en klanten en strategische allianties, op te bouwen en te onderhouden, steeds meer gezien als de sleutel tot duurzaam concurrentievoordeel (Omta en Van Rossum, 1999). Echter, de lijst van mogelijke samenwerkingsproblemen is lang. Kritische kwesties die hierbij een rol spelen variëren van: *Welk bedrijf levert welke bijdrage; hoe hoog zijn de coördinatiekosten; is het uitwisselen van kennis wel symmetrische genoeg* (‘outlearning de partner‘, Hamel, 1991), *en welk bedrijf profiteert het meest van de resultaten* (Farr en Fischer, 1992)? De conclusie kan dan ook worden getrokken dat het op open innovatie gebaseerde businessmodel niet een vanzelfsprekende keuze is. Bedrijven moeten zich dus de vraag stellen: *Levert het gebruik van het open innovatie businessmodel meer op dan de extra kosten die het met zich meebrengt?* Op basis van het aantal partners en de afhankelijkheden tussen de partners moet naar een goede balans tussen de verschillende bijdragen en de te verwachten resultaten worden gezocht. Om dit evenwicht te bereiken kunnen verschillende besturingsmechanismen worden gebruikt. In tegenstelling tot de samenwerkingsproblemen, zijn de besturingsmechanismen en de mogelijke wisselwerking tussen de verschillende besturingsmechanismen veel minder onderzocht. Dit boek stelt zich tot doel om deze leemte op te vullen.

Centrale doelstelling: Het analyseren van de verschillende besturingsmechanismen die gebruikt kunnen worden om de innovatieprestatie in netwerken (clusters) en in allianties te verbeteren om te komen tot aanbevelingen die gebruikt kunnen worden door alliantiemanagers, clustercoördinatoren en beleidsmakers voor het opzetten en in stand houden van (inter-)nationale en regionale innovatienetwerken en -allianties.

Verschillende theorieën zijn gebruikt om het innovatiemanagement in netwerken (of clusters) en strategische allianties te bestuderen. In hoofdstuk 2 is de innovatiesysteemtheorie gebruikt om de focus te leggen op de ondersteuning van clusters van bedrijven door cluster(coördinerende) organisaties. In hoofdstuk 3 is de ‘resource/knouwlege based view‘ gebruikt om de belangrijkste succesfactoren voor het opzetten en in stand houden van innovatieallianties te specificeren, terwijl in hoofdstuk 4 de ‘governance-perspective‘ tesamen met de ‘interdependency‘ theorie is gebruikt om nieuwe inzichten te verkrijgen over de verschillende besturingsmechanismen voor innovatieallianties. Tenslotte wordt in hoofdstuk 5 gefocused op kennisvalorisatie in een publiek-private onderzoekssamenwerking (PPRP), namelijk in het Centrum voor BioSystems Genomics (CBSG), om de invloed van de complexiteit van het innovatieproces, zoals weerspiegeld in de lengte van het productgeneratielevenscyclus (PGLC), op de door de private partners gewenste innovatieondersteuning door de publieke partner te bestuderen.

In hoofdstuk 2 wordt de innovatieondersteuning door clusterorganisaties van de bij de clusters aangesloten bedrijven bestudeerd (Omta en Fortuin, 2013, Klerkx en Leeuwis, 2008 en 2009, Batterink, 2009, Van Lente et al., 2003). Omdat er duidelijke verschillen zijn aan te wijzen wat betreft het technologische niveau van diverse sectoren, Er worden drie Nederlandse clusters in sectoren van verschillend technologisch niveau (op basis van de innovatie-input, Pavitt, 1984, Malerba, 2004) met elkaar vergeleken: een high-tech (elektronica), een medium tot high-tech (groene biotech) en een low tot medium-tech (agrovoedings-)cluster.

Onderzoeksvraag 1: Zijn er overeenkomsten en verschillen aan te wijzen wat betreft de innovatieondersteuning van de bedrijven door de clusterorganisatie in clusters in sectoren van verschillend technologisch niveau (elektronica, groene biotech en agrovoeding, 1a), en zo ja, wat kan er van de verschillen worden geleerd (1b)?

De gegevens werden verzameld door middel van 33 semi-gestructureerde interviews met de directeuren van de cluster organsiaties, regionale politici, onderzoekers in kennisinstituten en de innovatiemanagers van grote en kleine bedrijven uit de drie innovatieclusters (zie tabel 2.1). Met betrekking tot de functies van de clusterorganisatie werden een aantal overeenkomsten gevonden. Voor alle drie clusters kan worden geconcludeerd, dat de 'network formation support function', het faciliteren van de vorming van samenwerkingsverbanden tussen de bij het cluster betrokken bedrijven (Klerkx en Leeuwis, 2009) zeer belangrijk wordt gevonden. Clusterorganisaties bieden ondersteuning door het organiseren van seminars, workshops en ledenvergaderingen. In het elektronica- en biotechcluster wordt ook ervaring opgedaan met mogelijke samenwerkingspartners door het uitvoeren van gezamenlijke clusteractiviteiten door medewerkers van de bij het cluster betrokken bedrijven, zodat het cluster als het ware optreedt als één virtuele organisatie. Sector-onafhankelijkheid werd verder gevonden met betrekking tot de 'innovatieproces ondersteunende functie'. De resultaten tonen ook een aantal duidelijke verschillen tussen de drie clusters. Alleen de MKB-bedrijven in het agrovoedingscluster gaven aan behoefte te hebben aan ondersteuning om buitenlandse markten te bereiken, terwijl slechts in het groene biotechcluster de vraagarticulatie specifiek was gericht op de regio waar het cluster is gevestigd, bijvoorbeeld door het marketen van de betrokken regio als een aantrekkelijke woon- en werkomgeving voor hooggekwalificeerde medewerkers. En alleen in het elektronica cluster speelt de cluster organisatie een belangrijke rol in de opstelling van zogenaamde 'technology and market road maps', die technologische veranderingen en trends aangeven waarop de aangesloten bedrijven moeten inspelen opdat het cluster een leidende positie in de industrie behoudt. Dit instrument, ontwikkeld om de innovatieprocessen van de aangesloten bedrijven op sectorniveau af te stemmen, heeft een duidelijke invloed op de vraagarticulatie en netwerkvormende functies van de clusterorganisatie en zou ook een nuttig instrument voor het groene biotech en het agrovoedingscluster kunnen zijn.

In hoofdstuk 3 en 4 verplaatst de focus van dit boek zich naar het innovatiemanagement op alliantieniveau. Een innovatiealliantie is een samenwerkingsverband tussen twee of meer bedrijven met als doel om nieuwe kennis, producten en processen te ontwikkelen, terwijl ieder bedrijf zijn eigen identiteit behoudt (Hamel, 1991, Gulati, 1998, de Man en Duysters, 2005). Een literatuurstudie door Comi en Eppler (2009) wijst op een gebrek aan kennis omtrent het management van allianties. Het doel van hoofdstuk 3 is om deze leemte op te vullen door het samenwerkingsproces tussen MKB-bedrijven in de biotechsector te bestuderen om de kenmerken van succesvolle en van minder succesvolle innovatieallianties te vergelijken.

Onderzoeksvraag 2: Welke samenwerkingskenmerken zijn positief dan wel negatief gerelateerd aan de prestatie van innovatieallianties van MKB-bedrijven in de biotechsector?

Door te focussen op een goed onderzocht type innovatiealliantie, namelijk dat in de biotech sector, kan de basis worden gelegd voor een meer algemeen samenwerkingsmodel voor allianties. De verschillende fasen in het samenwerkingsproces worden onderzocht om de belangrijkste factoren die van invloed zijn op de alliantieprestatie te identificeren. Om onderzoeksvraag 2 te beantwoorden is een 'structural equation model'opgesteld (zie figuur 3.1), dat getest is met Partial Least Squares (PLS), op basis van een steekproef van 40 allianties van 18 Nederlandse MKB-bedrijven in de biotech sector. De belangrijkste hypothese: *Innovatieallianties met een hoge mate van complementariteit, waarin de cognitieve afstand tussen de deelnemers wordt overbrugd door intense kenniswisseling, bereiken een hoge mate van synergie en uiteindelijke een hogere innovatieprestatie*, wordt ondersteund door het gevonden PLS-model. De positieve padcoëfficiënten van 'resource-complementarity', het belang dat aan de alliantie wordt toegekend, het relationeel vertrouwen tussen de partners en een duidelijke taakverdeling naar de intensiteit van kennisuitwisseling en de positieve relatie van kennisuitwisseling met de exploratieprestatie tonen aan dat direct contact een belangrijke manier is om expliciete en impliciete kennis over te dragen in een innovatiealliantie. Verder zijn vertrouwen en een duidelijke taakverdeling positief gerelateerd aan de alliantieprestatie. Een duidelijke taakverdeling was ook positief gerelateerd via de alliantiesynergie aan de exploratie- en exploitatieprestatie. De negatieve padcoefficienten tussen relationeel vertrouwen, kennisuitwisseling en complementariteit met 'technology mapping' geven aan dat juist in gevallen waar de partners elkaar minder vertrouwen, bijvoorbeeld omdat ze elkaar minder goed kennnen, er gekozen wordt om tot een duidelijke afbakening van ieders technologiegebied te komen (bijv. middels octrooionderzoek). Het resultaat dat 'technology mapping' positief gerelateerd is aan het exploitatieresultaat lijkt aan te geven dat dit instrument met name gebruikt wordt indien een innovatiealliantie gericht is op de korte termijnontwikkeling van een produkt of proces.

Hoofdstuk 4 bouwt verder op hoofdstuk 3 door het gebruik van structurele en relationele besturingsmechanismen door de innovatiealliantiepartners te testen in een kwantitatief crosssectioneel onderzoek van 94 allianties in diverse Europese landen.

Onderzoeksvraag 3: Wat is de invloed van het gebruik van structurele en relationele besturingsmechanismen op de prestatie van innovatieallianties?

Structurele besturingsmechanismen verwijzen naar de taakverdeling binnen het samenwerkingsverband en naar de contractuele en niet-contractuele overeenkomsten over de wederzijdse inzet van personele en materiële middelen en de verdeling van de eventuele resultaten, alsmede naar de risicogerelateerde afspraken. Relationele besturingsmechanismen hebben betrekking op het belang van het opbouwen van vertrouwen op basis van werderzijds geaccepteerde informele normen en regels voor de coördinatie van een samenwerkingsverband. In de innovatieliteratuur is veel aandacht besteed aan relationele besturing, waarvan wordt verwacht dat deze meer, voor innovatie noodzakelijke, flexibiliteit oplevert dan de vaak als te rigide beschouwde coördinatie op basis van structurele besturingsmechanismen. Ons inziens wordt echter de rol van structurele besturingsmechanismen, vooral aan het begin van allianties als de partners elkaar nog niet zo goed kennen, onderschat. Om deze leemte in de management literatuur op te vullen werd een model opgesteld dat een innovatiealliantie conceptualiseert van de start tot aan het uiteindelijk resultaat. Deze werd getest met Partial Least Squares op basis van een crosssectionele dataset van 94 innovatieallianties in Nederland, België, Duitsland, Oostenrijk en Zwitserland. De resultaten in figuur 4.2 laten inderdaad de essentiële rol van structurele afspraken zien om een platform te creëren van vertrouwen waarop relationele besturingsmechanismen zich kunnen ontwikkelen, terwijl een duidelijke taakverdeling kan helpen om de complexiteit van het inter-organisationele innovatieproces te verminderen, door het verlagen van de wederzijdse afhankelijkheid van de partners. Deze twee structurele besturingsmechanismen maken de communicatie tussen de alliantiepartners gemakkelijker, wat leidt tot een hoger niveau van kennisuitwisseling en uiteindelijk tot een betere alliantieprestatie. Net als in hoofdstuk 3 blijkt dat 'resource complementarity, gecombineerd met een duidelijke taakverdeling, leidt tot een eenvoudiger uitwisseling van middelen en van 'tacit knowledge'. Risicoregerelateerde afspraken lijken met name gemaakt te worden in allianties die door het bedrijf zeer belangrijk worden gevonden. De negatieve relatie met taakverdeling lijkt aan te geven dat deze met name dan voorkomen indien het niet goed mogelijk is om tot een duidelijke taakverdeling te komen, bijvoorbeeld omdat de competentiegebieden te veel met elkaar overlappen. Net als in het ondezoek in hoofdstuk 3 lijken de resultaatgerelateerde afspraken met name voor te komen in allianties waarin produkten en processsen ontwikkeld worden die dicht op de markt zitten, waarbij afstemming tussen de partners minder nodig lijkt te zijn.

Hoofdstuk 5 gaat dieper in op de invloed van de complexiteit van het innovatieproces zelf in een Nederlandse publiek-private onderzoeksamenwerking (PPRP) in de plantenveredeling, namelijk in het Centre for BioSystems Genomics (CBSG). Hierbij is de PPRP gericht op kennisvalorisatie, het combineren van de middelen van de overheid met particuliere middelen (van zakelijke of not-for-profit organisaties) om maatschappelijke doelstellingen te behalen (Skelcher, 2005).

Onderzoeksvraag 4: Heeft de complexiteit van het innovatieproces,zoals weerspiegeld in de lengte van de levenscyclus tussen de verschillende productgeneraties (PGLC), invloed op het kennisvalorisatieproces in een publiek-private onderzoekssamenwerking (PPRP) in de sector plantenveredeling (4a), en zo ja, op welke wijze (4b)?

CBSG kan worden beschouwd als een combinatie van een aantal innovatieallianties die tesamen een netwerk vormen, bestaande uit 4 universiteiten, 2 onderzoeksinstituten en 15 bedrijven. Om de onderzoeksvraag te beantwoorden, werden gegevens verzameld bij alle 15 bedrijven die deelnemen in CBSG, 7 bedrijven zijn actief in de tomatensector met een gemiddelde PGLC van 5 tot 6 jaar en 8 bedrijven zijn werkzaam in de aardappelsector met een gemiddelde PGLC van 25 jaar of meer. Dit verschil is met name gebaseerd op de complexiteit van het kweken op basis van een diploïd genoom (tomaten) versus een tetraploïde genoom (aardappelen). De technische complexiteit van het plantenveredelingsproces blijkt de kennisvalorisatie te beïnvloeden. De resultaten laten een duidelijke relatie zien tussen de door de bedrijven gewenste valorisatieondersteunende activiteiten van CBSG en de lengte van de PGLC. De bedrijven uit de aardappelsector met een langere PGLC vragen duidelijk meer ondersteuning op het gebied van precompetitief, fundamenteel onderzoek en hebben meer behoefte aan geavanceerde communicatieinstrumenten, zoals technology monitoring en road mapping, om zicht te houden op de laatste technologische ontwikkelingen gedurende het complexe en langdurige innovatieproces. De tomatenbedrijven met kortere PGLCs, uitgedaagd om de ontwikkeltijd van nieuwe producten zo kort mogelijk te houden om geen marktkansen te missen, waarderen CBCG het meest voor de netwerkmogelijkheden en als leverancier van de nieuwste technische apparatuur en methodieken.

Tenslotte zijn in hoofdstuk 6 de management implicaties vertaald in een aantal aanbevelingen voor innovatiealliantiemanagers, clustercoördinatoren en beleidsmakers.

About the author

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