Innovation capabilities and governance in the agri-food sector

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This research was conducted under the auspices of
Wageningen School of Social Sciences (WASS)

Innovation Capabilities and Governance in the Agri-food sector

Mersiha Tepić

Thesis
submitted in fulfilment of the requirements for the degree of doctor
at Wageningen University
by the authority of the Rector Magnificus
Prof. dr. M.J. Kropff,
in the presence of the
Thesis Committee appointed by the Academic Board
to be defended in public
on Thursday 21 June 2012
at 11 a.m. in the Aula.

Mersiha Tepić
Innovation Capabilities and Governance in the Agri-food sector,
204 pages.

Thesis Wageningen University, Wageningen, NL (2012)
With references, with summaries in Dutch and English

ISBN 978-94-6173-297-2

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Preface and acknowledgements

Innovations are the result of the combination of strengths possessed by different people. Nor did the ideas and results from the present research come into effect without the common endeavour and support of several individuals. Therefore, I would like to thank a number of people who have helped and supported me during this research trajectory.

I would like to thank my supervisors, Onno Omta and Jacques Trienekens, as well as Frances Fortuin, for their guidance and advice during the years of my PhD work at the Management Studies Group. Onno always stimulated me to look even more critically at the data, analyses and drafts of my papers. I believe that we have spurred each other on to look at issues and discussions from different points of view. Although at times challenging, we always found a way to the best possible solution in our discussions. Jacques was always patient and willing to spend time and effort in rather long discussions about the conceptual developments of the research, the development of questions and questionnaires and the process of the writing of the papers. He was always available, whenever I needed advice or discussion to solve a problem. Also, I would like to thank Frances for her support and help specifically at the start-up phase of my PhD and during the Transforum project. In addition to my topic of research, we often discussed other interesting issues.

When it comes to the project work, I would like to acknowledge the financial support from Transforum which enabled my research and provided data collection possibilities with regards to the innovation projects in agri-food networks. Transforum was the important link which provided the possibility to establish contact with project managers from several innovation projects in these networks. In addition to interviews, other information sources useful for the present study were also enabled by Transforum. In the context of the Transforum project, I would like to acknowledge the pleasant and insightful collaboration with the project team from Tilburg University, including Prof. dr. M.T.H. Meeus and A.C. Smit, MSc. I would also like to thank Chris Peterson, professor in the Department of Agricultural Economics at Michigan State University for his useful comments on the study in Chapter 5.

Furthermore, I would like to acknowledge the financial support provided by the EU 6th Framework Q-pork chains project which enabled the additional data collection for the large-scale survey in Chapter 4. The project provided the opportunity to prolong my research and conclude it with even more interesting research output than initially planned.

The studies in Chapters 2 and 3 are made possible by the use of a database (WIAT) which was collected with the aid of several people. Therefore, I would like to thank Jan Hollander for his contribution to the dataset, and Maarten Batterink, Frances Fortuin, Emiel Wubben and Onno Omta for the time and effort which they have put into enlarging the database. Special thanks go to Ron Kemp, who has been very helpful with the analysis of data, especially with

regards to the research in Chapters 2 and 3, but also with other (methodological) questions, in general.

In addition, I would like to acknowledge and thank Robert Hoste from the Agricultural Economics Research Institute, for his help, comments and advice in the set-up and analysis of the research in Chapter 4. He provided specific information about the practical developments in the pork sector and pig farmers in particular, and became co-author of the study in Chapter 4. By joint research and several discussions, MSc student, Ronald Sol has also been helpful in providing additional information for the study in Chapter 4.

I would also like to thank Nico Overbeeke, a former director of Unilever R&D Vlaardingen and Vice President of Unilever Foods Research, for enabling a set of interviews with Unilever employees and their international partners. Although the results from this research are not included in the present thesis, they have generated valuable insights about the organisation of such innovation processes which I used in my research.

I would also like to thank the members of my dissertation committee, including Prof. dr. Geert Duysters, Prof. Mr. Dr. B.M.J. van der Meulen, Prof. dr. M.T.H. (Marius) Meeus and Dr. Loïc Sauvée, for the evaluation of and participation in the defence of the present thesis.

Special thanks and acknowledgement go to the members of the Management Studies Group who have been pleasant colleagues over the years. Many of these colleagues, as well as colleagues from other departments, were of great value, not only for discussions about the research topics addressed in this thesis, but also in terms of further development of ideas about research in general, ideas about experiences and growth through career development and cultural differences and similarities. The nice moments, chats, sports and social activities with a large number of colleagues provided considerable added value throughout these years of research at the Management Studies Group. Also, I would like to thank Leonie van Scherrenburg, Ina Versteeg and Jeannette Lubbers-Poortvliet for their support and help throughout the years.

I would like to thank especially my closest family, my mother, sister and brother for all of their support and encouragement. Last, but not least, I would like to express my appreciation for the ability to share my life with one of the kindest and most tolerant people I have ever met. My partner has been a great support for many years, and especially during the time of my PhD research, he encouraged and supported me greatly.

1. Introduction

The agri-food sector is an important economic sector in Europe and in the Netherlands. The European agri-food industry has a leading global exporter role and stimulates the development of regional and national economies in Europe. In the Netherlands, the agri-food industry is distinguished as one of the top sectors by the government which means that it constitutes an essential part of the Dutch economy, with a contribution of almost 10% to the GDP. Innovation plays an important role in the agri-food sector, as this sector is facing several challenges, such as the increasing worldwide demand for food, the ageing population and related health problems, and increasing competition for scarce resources. Increasingly, innovation has gained in importance for the mature agri-food industry to face the fast changes in the technological, economic, environmental and societal fields. Environmental problems are receiving increased societal attention. Also ethical issues, such as animal welfare and genetic modification, impose societal demands on the agri-food sector. However, technological developments, such as genetic mapping or DNA marker technology, offer new possibilities for change and innovation. The vision and capabilities to manage these innovations are required to embark upon and exploit these possibilities (see Box 1).

The approach to innovation has developed over the years. The focus has shifted from different types of in-house innovations, to knowledge absorption through interaction with external actors, to innovation in partnerships to attain cross-company benefits.

In-house innovations can differ per agri-food sector. For example, innovations in the plant sciences differ from innovations in the cattle or pork sector. Innovations in the former are related to changes and developments in seed, fertilisation and soil or developments in the management of greenhouses, whereas innovations in the latter are more related to feed or stable adjustments. Innovations also differ per type of chain actor. For example, farmers may engage in changes to their stables to improve the welfare of their animals, whereas large food processors may engage in basic research looking for innovations in additives to improve the

Box 1.

The use of new technologies, such as DNA marker technologies, enable breeders to halve the time needed to breed a new crop, compared to 15 years ago. DNA markers are comparable to easily recognizable flags on the DNA that indicate the presence of useful or desirable genes. They allow breeders to predict already in the laboratory which traits a plant will probably show in the field, or when packed in a can or plastic. This means that a relatively small number of varieties have to be cultivated, cut and wrapped. However, breeders can only find the accurate DNA markers and genes for a trait if they have enough information about the characteristics of the crop, its processing and the end product. Therefore, breeders need input from farmers, but also from processors.

(Food Valley, 2011).

taste or smell of food. While they engage in very different types of innovation, the level of innovativeness does not have to differ between the farmer and the food processor.

An open approach to innovation is one where firms can and should use internal and external ideas and paths to the market in their quest for new technologies and innovations (Chesbrough, 2003). In a world of widely distributed knowledge, the boundaries between a firm and its environment have become more permeable and innovations can enter and exit the firm. Many companies cannot afford to rely entirely on their own research efforts and therefore the buying in or licensing of inventions from other companies became a prevalent approach. For many agri-food companies, it is essential to engage in collaborations with other chain actors and different disciplines to be able to innovate using technological developments, such as probiotics, new breeding techniques or innovative market concepts. Engagement in interaction and collaboration is not only motivated by the inability to specialise in a lot of different areas. Collaboration can also help to address difficulties related to, for example, resistance to particular developments. Consumers are wary about changes in their food, especially when changes take place that conflict with their norms and ethics, or which go beyond their understanding. Societal pressures are exerted on the food sector opposing practices such as genetic modification, and neglect of animal welfare and the environment. In order to meet this complexity of demands, actors from the agri-food sector are stimulated to engage in collaborative innovation processes with a wider network of actors, for example in the form of public private partnerships. Such partnerships can help them to achieve innovation goals which would otherwise never have been attained (see Box 2).

Box 2.

In a south-east region of the Netherlands, a Greenport is developed where traditional compartmentalized, spatial planning is exchanged for spatial development policy. Here, learning takes place in networks which connect entrepreneurs, government and people who live in the area, encouraging innovation. This new network creates an environment where new, sustainability-oriented business cases can be developed through collaboration among entrepreneurs from different sectors and with support from governmental institutions and the community. For example, there is the Cradle-to-Cradle development of an industrial area, 'Klavertje Vier'. This new network is anchored through the set-up of a Greenport House where entrepreneurs, government and research institutes collaborate to support new business ideas and initiatives.

(Transforum, 2010)

1.1 Challenges to be addressed

While firm performance is increasingly dependent on the continuous improvement and introduction of new products, innovation is costly, time-consuming and characterised by many uncertainties. Different chain actors encounter different challenges in the several stages of the innovation process. These include uncertainties about the way in which the process will evolve over time, whether the outcome of the innovation process will be successful and whether it will result in a high return on investment. For example, 44% of innovation projects fail to achieve their profit targets (Cooper and Edgett, 2009). Only one product concept out of seven becomes a new product winner and half of all new product launches are late to the market (Cooper and Edgett, 2009). In-house innovation projects impose organisational requirements on companies, such as the organisation of the suitable resources and skills, but also coordination requirements, such as the division of responsibilities (manager/project leader, sub- or working groups, supervision and monitoring requirements), and organisation of internal knowledge transfer (brainstorming, meetings, reporting and distributing knowledge about new developments). The uncertainties inherent to innovation processes create (hidden) organisation and coordination costs, because developments during the innovation process may require changes and anticipation and increase the costs of organisation of the process.

Next to in-house innovation, interaction with external sources for the purpose of exchange and absorption of knowledge is considered one of the most important ways in which firms can innovate (Cohen and Levinthal, 1990; Burt, 2005). However, also here, there are organisational challenges as skills and capabilities are required to assess the importance of specific actors as sources of knowledge, and the frequency and extent of contact with these actors. Interaction and the search for information and knowledge from external sources is a time-consuming activity which requires a specific approach towards its organisation to prevent the costs of interaction and coordination from exceeding the benefits.

Innovation projects and processes in networks come with the advantages of sharing resources, expertise and funding, but the involvement of multiple actors in the innovation imposes even higher organisational or coordination costs than in-house innovation projects. These coordination costs can be an effect of organisational differences, such as dissimilar organisational structures or cultural and norm differences. When multiple organisations are involved in a project, the complexity and difficulty of coordination activities increases (Hobday, 2000). Distance reduces opportunities for spontaneous, informal talk in a shared social setting (Kiesler and Cummings, 2002). More time and effort is required to foster a collegial social environment (Kraut *et al*., 2002; Nardi and Whittaker, 2002), build common ground (Clark and Brennan, 1991), maintain awareness of what others are doing (Weisband, 2002), and make rapid adjustments to unexpected developments (Olson and Olson, 2000). Advances in communication and computer technology have reduced the costs of coordination to an extent. However, these solutions can never actually replace face-to-face interaction and monitoring. Moreover, organisation and coordination costs can increase as a consequence of

misunderstandings (Cramton, 2001), institutional rivalries (Armstrong and Cole, 2002), free riding (Weisband, 2002), following the priorities of the own firm while neglecting the common aims, inconsistent procedures across firms and organisations (Curtis *et al*., 1988), a failure to share information and communicate effectively (Hinds and Mortensen, 2005; Hoegl and Proserpio, 2004), and unlawful/unfair appropriation of innovation outcomes. Uncertainties inherent to innovation, but also inherent to interaction and collaboration with external actors, therefore, increase organisation and coordination costs. Adequate management is required to prevent the costs from exceeding the benefits.

In the present thesis, it will be studied how to address the organisational challenges stemming from innovation in general, and from interaction and collaboration with actors from the chain and the network. The focus of the present study is on the internal and external organisational capabilities of firms and governance mechanisms in innovation partnerships to enhance innovation performance.

The main objective of this book is to analyse, within the agri-food sector, the relationship between:

- *internal and external organisational capabilities and firm innovation performance*;
- *structural and relational governance mechanisms and inter-firm innovation performance*.

Accordingly, insights about in-house innovation management, external knowledge absorption and co-innovation will be combined to provide an overview of the necessary organisation and managerial approaches for high-performing innovation processes. A first question concerns the internal functional and integrative capabilities of the firms to improve innovation project performance. Often, internal resources and skills fail to provide for sufficient problem-solving. Therefore, the questions of how the missing resources, knowledge and skills can be acquired externally through the firm's organisation of networking and absorption, is addressed. In the case of external interaction, for example in the form of co-innovation partnerships, exchange of resources and knowledge with external actors is undertaken, which requires governance mechanisms to deal with differences among partners, potential opportunistic behaviour and uncertainty of the outcome of the innovation process. These issues are also addressed in the present study.

Many companies, but also governmental institutions, emphasise the merits of innovation, especially at times when economic crisis puts major strains on the survival of companies. In order to increase the probability of successful innovation, these actors need to be aware of the necessary skills and capabilities to deal with the challenges of innovation and collaboration. The present study can be used by companies, and more specifically companies from the agri-food sector, to learn about the firm skills and capabilities needed for the management of in-house innovation projects, and organisation of interaction with actors from the chain and the network to absorb external knowledge. Policy-makers can increase their insight about the way in which co-innovation partnerships in the agri-food sector can be organised and managed.

From the theoretical point of view, the study adds to the existing research about innovation management by specifying and studying the internal and external firm capabilities for in-house innovation and governance mechanisms which can enhance innovation performance in inter-firm/co-innovation partnerships.

1.2 The management of innovation

According to Schumpeter (1934), innovation of a product, process or business model can be expressed as the level of output novelty, such as a new good or a new quality of a good, a new method of production, a new market, a new source of supply, or a new organisational structure. Debate continued about the criteria for an invention to qualify as an innovation, for example its necessity and sufficiency (Pittaway *et al*., 2004), its beneficial nature (Camison-Zornoza *et al*., 2004), or its diffusion (Holland, 1997). Crossan and Apaydin (2010) introduced a new definition where they define innovation as production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and establishment of new management systems. It is both a process and an outcome (Crossan and Apaydin, 2010, p. 1155). This definition includes both internally developed and externally adopted innovation. It includes the aspect of exploitation which indicates the importance of applicability of innovation, and it includes the possibility that innovation may refer to the relative, as opposed to the absolute, novelty of an innovation.

Over the years, different determinants of innovation performance have been established. These range from technological resources that are concerned with managing the accumulation of knowledge and experience about technologies to the managerial and organisational factors such as team communication, cross-functional innovation teams, leadership and research culture. The first generation of R&D management (1950 to mid- 1960s) was based on the philosophy that more R&D would produce more products. The innovation process was considered linear and pushed by technology (Nobelius, 2004). This led to a focus on investment in corporate research labs where technology has the chance to evolve. The 2nd generation of R&D (mid-1960s to early 1970s) was marked by the emphasis on the short-term demand side of innovation, where the market-pull was emphasised. Project management was introduced to direct and monitor the R&D activities in line with customer preferences. From the mid-1970s to the mid-1980s, the high inflation rates and demand saturation led the management to focus on cost control and reduction. Accordingly, the 3rd generation R&D management put the focus on portfolio management, concentrating on balancing the risk-reward continuum of probability of technical and market success (Nobelius, 2004). Greater emphasis was put on project and portfolio management, structured design methods and analysis/evaluation of long-term strategies. The 4th generation (early 1980s to mid-1990s) reconsidered the diversification strategy, putting the focus on core business and shifting from development of products to putting the product in a total business concept (including services, distribution and multi-product platforms). Integration and paralleling of R&D with the involvement of

lead customers and suppliers in the innovation, in order to increase cross-functionality, were considered success factors for speedy innovation processes.

With changes and developments such as globalisation and changing organisational methods of employing innovation (i.e. cross-firm-boundary alliances), the developments in the approaches and views on innovation management continued. A 5th generation of innovation and R&D management (mid-1990s onward) was developed, shifting the focus to interaction with the environment (competitors, distributors, customers, suppliers) which enables integration and coordination of systems from different actors. This generation of innovation management not only focuses on the speed of the innovation process, but more importantly, on the timeliness of the innovation. It is about the reduction of uncertainty while strengthening the efficient and effective integration of a coherent whole. The firms are adopting a cross-boundary alliance strategy, involving the company network in both research and development, and linking research to development to enhance the overall precision (Nobelius, 2004; Ortt and Van der Duin, 2008). The complexity of R&D increased due to the need to take more aspects into account (e.g. interoperability, industrial design, environmental, manufacturability, and after-market considerations), due to the demand to cooperate and interact with more actors outside the traditional R&D departments (e.g. with marketing and manufacturing functions, with suppliers, competitors, and distributors), and the necessity for efficient and effective commercialisation of new technologies (e.g. timely, efficient deliveries of new products with predictable quality) (Nobelius, 2004; Ortt and Van der Duin, 2008). The 6th generation is expected to re-focus on the research part of R&D but in the sense of a broader multi-technology base for high-tech products and broader technology-sourcing strategies, including technology company acquisitions, intellectual property acquisitions, joint ventures or independent research groups or networks (Nobelius, 2004; Ortt and Van der Duin, 2008). The focus is on offering functionalities to the customer, irrespective of which combinations of devices are used. The combinatory capabilities of companies, in particular, become important for the purpose of establishing loosely tied alliances with disperse actors (universities, temporary interest groups and competitors) crossing expertise and technologies. The aim of this 6th generation R&D is then also to develop breakthroughs which affect entire industries and involve larger risk-reward ratios.

1.2.1 Innovation performance

The changes in the approaches to innovation and the way in which innovation should be organised were also reflected in the way in which, and the level at which performance was measured. In the present study, distinction is made between the measurement of performance at the firm and at the inter-firm level. Firm level performance can result from in-house innovation projects, internalisation of external knowledge and translation into in-house innovations, as well as gains from inter-firm partnerships. The latter can also result in outcomes, gains and benefits which for example benefit the sector in general.

Firm level innovation performance

Increased innovation performance can be based on the development of a manufacturing or service process that is faster and more productive than that of competitors, or a new product that creates customer value through quality and the ability to fit with market needs. Innovation performance can be measured in terms of input or in terms of output. Input measures take into account the resources put into the process to execute the innovation process (Hagedoorn and Cloodt, 2003). Output measures help to determine whether the objectives are accomplished. It is, for example, assessed whether the project exceeded the planned budget and time, and stayed within the original (technical) specifications or objectives (Hollander, 2002; Salomo, Weise and Gemunden, 2007). The project organisation of the innovation process makes the innovation project performance criteria a cardinal point for assessing innovation performance. Next to project performance, innovation performance measures can also take into account the overall firm or the technical or R&D unit performance. Examples of parameters used to determine innovation performance include the number of new products developed in the last few years as a percentage of current sales (Cassiman and Veulegers, 2006; He and Wong, 2004) or the new product success rate (Cooper, 1995; Maidique and Zirger, 2009). It is often rather difficult to assess the contribution of innovation to financial performance such as profitability or return on investment (Tidd, 2001). Therefore, technical performance of innovation is usually established on the basis of non-monetary measurements, such as the number of patents or publications (Acs and Audretsch, 1989; Bresman *et al*., 1999; Freeman and Soete, 1997; Patel and Pavitt, 1995; Pavitt, 1988). The multidimensional evaluation of projects by managers of R&D organisations, rating a set of quantitative and qualitative criteria, is also used to establish innovation performance (Salomo, Weise and Gemunden, 2007).

With the developments towards a more open way of innovation, around the mid-1990s, where innovations can enter and exit the firm, the measurement of innovation performance changed. The traditional measures of goal achievement, productivity, profitability or return on investment were complemented by measures such as the contribution of networking activities to the performance of the firm. This is done, for example, by looking at the impact of engagement in R&D cooperation on innovation performance, in terms of sales of innovative products (e.g. Klomp and Van Leeuwen, 2001; Janz *et al*., 2003; Van Leeuwen, 2002; Faems *et al*., 2005), patenting (Vanhaverbeke *et al*., 2001), and sales growth (Cincera *et al*., 2004).

Inter-firm level innovation performance

At the inter-firm level of innovation (projects), performance is usually defined on the basis of a combination of measurements. Next to the contribution of participation in a network to the goal achievement, productivity, profitability or return on investment of the company, also parameters related to the cross-company benefits ought to be considered. Measurement of performance at the network level is complicated by the different participants in the collaboration. They may not have the same goals for participating in the network, their firm-

level performance may not be measurable by the same parameters and different participants from the network may benefit to different extents from the collaboration. Accordingly, intangible outcomes, such as strategic goals, long-term benefits of learning and accumulation of knowledge and experience also became part of the performance indicators for collaboration (Sydow and Windeler, 1998).

1.3 Theoretical framework

The changes in the approaches to innovation and the way in which innovation should be organised were not only reflected in the measurement of performance, but can also be interpreted in the development of organisational theories and views. This section will elaborate on these theoretical developments and the consequences for the views on the management and organisation of innovation. As explained, the focus of innovation management was directed first at the innovation processes and projects inside the boundaries of the firm. In this regard, the resource-based view (RBV) and the stream of research which emphasises the capabilities within the RBV will be introduced in the present study (see Figure 1.1). Later, the attention shifted towards an outward orientation where more emphasis was put on absorption of knowledge, resources and skills from the external environment and collaboration with actors from the chain, other sectors and disciplines to enhance the own innovation performance. In this regard, the knowledge-based and dynamic capabilities views are introduced where the emphasis on knowledge absorption and learning, through the means of networking, is studied (see Figure 1.1). Within the context of external orientation, the structural and relational governance perspectives are also introduced, which point to the necessary governance mechanisms to manage the inter-firm innovation partnerships (Figure 1.1). With the aim of analysing the effect of in-house and network-oriented organisational capabilities on the

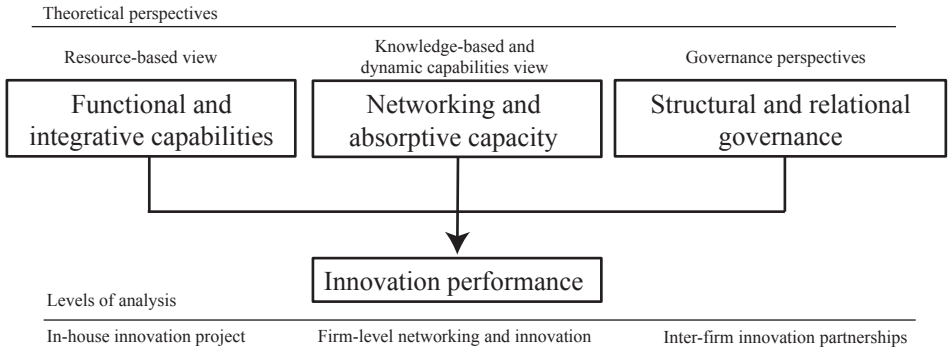

Figure 1.1 *Organisational capabilities to enhance innovation performance through in-house and open, network-oriented innovation projects and processes.*

innovation performance of (firms in) the agri-food sector, different perspectives, as depicted in Figure 1.1, are employed. In the following part, these theoretic approaches will be set out.

1.3.1 Resource-based view (RBV)

The views of the first 4 generations of R&D/innovation management are mainly linked to theoretical developments about outside-in and inside-out business strategies. The focus on market-pull is closely linked to the outside-in perspective which stresses that firms should identify attractive market opportunities where they can focus on customers' preferences which are not (sufficiently) covered by other firms (Mintzberg, 1990). In this case, the innovation strategy entails close collaboration between R&D and marketing and sales in order to assure that the customer preferences are integrated into the innovation projects. Instead of the external customer orientation, the inside-out perspective, known as the resource-based view, states that resources are firm assets that directly contribute to an organisation's business. Barney (1991) defines resources as all the assets, capabilities, organisational processes, knowledge, etc. controlled by a firm that enable the conception and implementation of strategies to improve firm efficiency and effectiveness. Tangible resources are machines, equipment and real estate, while intangible resources are carried by the employees of firms in the form of knowledge and skills or can be organisation-specific in the form of reputation or image. The core claim of the resource-based view (Wernerfelt, 1984) is that firms within an industry may be heterogeneous with respect to the strategic resources they control and that these resources may not be perfectly mobile across firms (e.g. Barney, 1991; Dierickx and Cool, 1989; Lippman and Rumelt, 1982; Peteraf, 1993). In this way, the resource-based view stresses the firm's internal strengths, which are unique and difficult to imitate as the key aspects which can distinguish the firm from its competitors and lead to competitive advantage (Barney, 1991; Peteraf, 1993; Wernerfelt, 1984, 1995).

The resource-based view of the firm evolved with the claim that while tangible resources, such as physical and financial assets, and the intangible resources, such as human capital and reputation, are important for the competitive advantage of the firm (Amit and Schoemaker, 1993; Grant, 1991), it is the strength of capabilities which is idiosyncratic because they develop over time. Capabilities[1] are especially important in the context of innovation performance, because innovation requires creative and innovative re-combination of resources and skills (e.g. Amit and Schoemaker, 1993; Grant, 1996; Prahalad and Hamel, 1990; Teece *et al*., 1997) to attain superior or rapid introduction of new products in the market. Capabilities reside in routines that are intrinsically intangible (e.g. Conner and Prahalad, 1996; Itami and Rohel, 1987; Kogut and Zander, 1992; Leonard-Barton, 1992; Winter, 1987) and difficult

[1] Capacity can also mean ability, but it implies that one 'contains' the ability to do something. There is a metaphorical meaning of space ingrained here which indicates the potential to succeed for whatever reason.
Capability is the ability, quality of being capable, or a potential aptitude. When the capability to do something is referred to, then it means that there is physical, mental, or cognitive ability or skill that helps in doing something. Competence refers to specific knowledge and skill, such as legal competence.

to duplicate. For example, the way in which problem-solving is managed can affect innovation performance. Problem-solving capabilities originate from activities undertaken (Leonard-Barton, 1995) in conditions of uncertainty, complexity, and conflict (Amit and Schoemaker, 1993) and require social interaction for the continuous conversion of tacit and explicit knowledge (Nonaka, 1994).

Different types of capabilities are distinguished but two of these types are often referred to and considered as important in the context of innovation. Functional capabilities are related to the deepened and adequate functional knowledge, in terms of technology, manufacturing and marketing (e.g. Pandza, 2005; Amit and Schoemaker, 1993; Grant, 1991; Henderson and Cockburn, 1994; Pisano, 1996; Prahalad and Hamel, 1990; Snow and Hrebiniak, 1980), while the integrative capabilities contribute to combination and assimilation of the different competencies developed in various company departments or bind the different functional capabilities (e.g. Grant, 1996; Henderson and Clark, 1990; Iansiti and Clark, 1994; Kogut and Zander, 1992; Pisano, 1996; Teece *et al*., 1997; Pandza, 2005). There are a number of functional capabilities which are important for innovation performance. Technological, or upstream, capabilities involve R&D knowledge, technological complementarities and manufacturing knowledge (Pandzo, 2005; Hayes *et al*., 1996; Hayes, Wheelwright, and Clark, 1988; Helfat, 1994) which enable the firm to execute the innovation tasks adequately. Downstream capabilities entail marketing capabilities concerning the screening, use, and dissemination of market information (Day, 1994; Hunt and Morgan, 1995). Next to the capturing of customer needs, wants, and preferences, market-related capabilities also entail sales, distribution, and services (Montgomery and Hariharan, 1991). Strategic-marketing capabilities entail decision-making about market segmentation and product differentiation to affect the way customers perceive a new product's ability to fit with their market needs (Hamel and Prahalad, 1991), as well as the way in which decisions about pricing, distribution and advertising can enhance (the perception of) the quality of the product (Urban and Hauser, 1993).

Integrative capabilities are also important for innovation performance. Process-related integrative capabilities are studied in the form of communication among innovation project team members which is found to be positively linked to speed and productivity of the innovation process (Brown and Eisenhardt, 1995, 368). Previous research about innovation found that team interaction, knowledge sharing and communication have a positive effect on process project performance (Imai *et al*., 1985; Katz, 1982; Zirger and Maidique, 1990; Brodbeck, 2001; Keller, 2001) as well as on the output of innovation projects in terms of number of patents and commercialised products (Allen, 1984; Visart, 1976). Frequent communication can enhance the understanding, level of knowledge and problem-solving among the team members, such that they become more efficient in gaining and using the circulating information (Brown and Eisenhardt, 1995).

Besides communication, Iansiti (1997) and Pisano (1994) highlight the integration of different internal sources of technological knowledge (i.e. R&D, design, engineering,

and manufacturing) as a primary driver of lead time and productivity. Strategies based on extensive planning and problem-solving also entail these integrative capabilities which have a positive effect on innovation performance (Brown and Eisenhardt, 1995, 369; Thamhain and Wilemon, 1987; Thamhain, 1996). As West and Anderson (1996) conclude, clear direction-setting enables the focused development of ideas and assessment with greater precision.

Contribution to RBV in innovation management research

Up to this point, research on the resource-based view has touched upon innovation from a strategic point of view, where the resource-based approach is framed in a dynamic context. It is argued that Schumpeterian competition, which involves carrying out 'new combinations' (Iwai, 1984), may be translated into the resource-based framework by considering the firm's new combinations of resources (Penrose, 1959) to be achieved through accumulation of knowledge through R&D and learning as strategic asset (Winter, 1987). As Mahoney and Pandian (1992) argue, the Schumpeterian perspective and the resource-based view are combined by Rumelt (1984) by arguing that strategy formulation consists of a constant search for ways in which the firm's unique resources can be redeployed in changing circumstances (Rumelt, 1984). Later, Verona (1999) addressed the functional, and internal and external integrative capabilities in the context of new product development while focusing on the development of an agent-resource model.

Kleinschmidt, De Brentani and Salomo (2007) address the resource-based view in the context of innovation by pointing to the evolutionary and dynamic character of the firm capabilities through skill acquisition, learning, and accumulation of organisational and intangible assets over time (Teece *et al*., 1997). They emphasise that organisational resources are considered as less productive in themselves and more as working through a firm's ability to assemble, integrate, and manage them via organisational capabilities (Eisenhardt and Martin, 2000). Also, this study demonstrates that most research which addresses the capabilities of the firm immediately makes the link to the interaction with external actors and environment for knowledge acquisition purposes, without sufficiently addressing the link between the resource-based view and the capabilities necessary for in-house innovation. The present study addresses this gap by embarking on the resource-based view capabilities which are important for in-house innovation, and linking these to the other determinants of innovation performance identified by e.g. Cooper *et al*. (1989; 1993). Firm capabilities, instead of resources, are given specific attention because capabilities enable deployment and coordination of different resources in the context of innovation, characterised by problem-solving (e.g. Dosi and Marengo, 1993; Von Hippel and Tyre, 1994), uncertainty, complexity and conflict (Amit and Schoemaker, 1993).

1.3.2 The knowledge-based and dynamic capabilities perspective

The developments in innovation management led to an emphasis on knowledge as one of the core assets/resources of innovation processes. In innovation, knowledge is among the most

important assets to be exchanged with, or acquired from, actors beyond the borders of the company. This emphasis on knowledge led to the development of the knowledge-based view, which originates from economic analyses of the decision about whether resources should be developed within the organisation or acquired from external sources. The knowledge-based view posits that specialised expertise (human capital) is the most important asset for firms engaged in knowledge-intensive activities (Kogut and Zander, 1992; Grant, 1996). Organisations which aim to improve their competitive advantage through innovation need to draw from a pool of different types of expertise (Cummings and Kiesler, 2007). Within this knowledge-focused doctrine, it is argued that organisations and project teams which are more effective at integrating the different level of expertise are more successful (Grant, 1996). The capacity of the firm to accumulate knowledge and learn is thus related to the firm's combinative or integrative capabilities.

The knowledge-based view postulates access, accumulation and building-up of knowledge as imperative determinants of the competitive advantage of the firm. Interest in the concept of knowledge absorption started with the organisational learning literature in the 1980s (Fiol and Lyles, 1985; Levitt and March, 1988; Cohen and Levinthal, 1990), followed by many empirical studies which point to the notion of absorptive capacity (Ahuja 2000b, Cockburn and Henderson 1998, Lane and Lubatkin 1998, Lyles and Salk 1996, Mowery *et al*., 1996, Pisano 1994, Powell *et al*., 1996, Shane 2000, Tsai 2001). At the individual level, knowledge sharing and knowledge recognition are important for the building-up of knowledge, while at the organisational level routines, histories, stories, documentation, procedures and tacit know-how or skills establish common understanding (Grant, 1996; Matusik and Heeley, 2005). Cohen and Levinthal (1990) distinguished organisational mechanisms, such as transfer of knowledge across and within units, the structure of communication between the external environment and the firm, the breadth and intensity of network interactions and cross-functional exchanges, as determinants of absorptive capacity. Knowledge flows or transfers of knowledge are imperative for the recognition, assimilation and utilisation of knowledge (Foss, 2006). A firm's connectedness to external sources of public and private knowledge (Powell *et al*., 1996; Cockburn and Henderson, 1998; Todorova and Durisin, 2007) and interaction within the network and the supply chain is rewarding for the firm, enabling it to acquire access to knowledge, facilitate learning processes, and foster knowledge creation (Van Wijk *et al*., 2003; Malhotra *et al*., 2005; Lane *et al*., 2001, Benson and Ziedonis, 2009).

The dynamic nature of absorptive capacity was emphasised and elaborated by the introduction of a dynamic capabilities perspective of absorptive capacity by Zahra and George (2002). They define absorptive capacity as '*a set of organizational routines and processes, by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability. These four dimensions have a complementary role in explaining how absorptive capacity can influence organizational outcomes*.' The definition of Zahra and George differs from previous studies because it views absorptive capacity as a dynamic capability embedded in a firm's routines and processes, and because it suggests that the four capabilities are combinative in nature and

build upon each other to produce a dynamic organisational capability. The absorptive capacity of a firm can be stimulated through different processes (Cohen and Levinthal, 1990; Teece *et al*., 1997), structures, managerial systems (Henderson and Clark, 1990; Leonard-Barton, 1992; Ulrich and Lake, 1990), networks (Eisenhardt and Bird Schoonoven, 1996; Grant, 1996), or culture (Kogut and Zander, 1996; Leonard-Barton, 1992). Next to communication (Brown and Eisenhardt, 1995), other processes of integration of external and tacit knowledge are also identified (Grant, 1996), such as observation and emulation of external technical experts (Nonaka, 1991) which can further enhance the knowledge of engineers and product managers (Iansiti and Clark, 1994). Also incentives and rewards are considered as a way of integrating external knowledge. For example, the promotion of researchers according to their standing in the scientific community has a positive effect on the level of productivity. Through research, writing of papers, and attending conferences, an extensive flow of knowledge across organisational boundaries is maintained. In addition, external knowledge can be imported through integrative structures and culture. For example, an R&D network based on strong formal ties to suppliers can enhance (innovation) performance (Nonaka, 1990), but also technological knowledge absorption from collaborations with different institutions is effective (Iansiti and West, 1997).

Contribution to research on absorptive capacity

Previous research, by for example Jansen *et al*. (2005), explores the role of coordination, socialisation, and systems capabilities as antecedents of different dimensions of absorptive capacity. These researchers find that coordination capabilities (i.e. cross-functional interfaces, participation, and job rotation) enhance acquisition and assimilation capacity of organisational units, while socialisation capabilities (i.e. interdepartmental connectedness and socialisation tactics) are the primary contributors to the transformation and exploitation capacity of organisational units. Also, the way in which organisational forms, such as functional, divisional and matrix forms, affect the different dimensions of absorptive capacity in terms of efficiency, scope and flexibility of knowledge integration (De Boer *et al*., 1999; Van den Bosch *et al*., 1999) is regarded. While these studies consider these organisational aspects and mechanisms as antecedents of absorptive capacity, in the present study, we return to the definition of Zahra and George (2002) of absorptive capacity as a dynamic organisational capability and explore the '*multidirectional and fluid path, rather than a patterned trajectory of knowledge acquisition and exploitation*' (Zahra and George, 2002, p. 198).

This focus on absorptive capacity as a dynamic organisational capability is extended further to another area which touches upon absorption of knowledge and absorptive capacity. With knowledge as one of the main resources exchanged in external relations which are established for the purpose of innovation, also literature which studies the structural and relational engagement in external relations/networks from a strategic point of view has embarked on the concept of absorptive capacity. These studies, which take a social network perspective, study the relationship between network position, absorptive capacity and business performance

(Tsai, 2001), or between network cohesion (overlapping ties among mutual third-parties) and network range (relationships that span multiple knowledge pools), where control variables are supposed to explain the variance which can be attributed to absorptive capacity (Reagans and McEvily, 2003). In such studies, absorptive capacity is often considered as the technological distance between companies engaged in collaboration (Van Gilsing *et al*., 2008), or other proxies, such as a firm's total expenditures on in-house R&D activities and training programs, or the number of employees that have an academic degree in a scientific or engineering field (Caloghirou *et al*., 2004). Absorptive capacity, as a dynamic organisational capability of the firm, is often disregarded. Insights from the social network theory about structural holes bridging organisational boundaries (Burt, 1992; Rosenkopf and Nerkar, 2001) and strong ties (Granovetter, 1982; Krackhardt, 1992) are used to hypothesise on the form which networking capability should take to organise the acquisition of external knowledge.

1.3.3 The governance perspective

Next to ideas about strategic orientation towards knowledge acquisition, the knowledge intensive economy also caused fundamental changes in the economic organisation and its governance. The increasing disaggregation of firms through outsourcing and out-licensing and the predominance of knowledge and human capital (over physical capital) for value creation are changing the boundaries of the firm (Foss, 2007). Innovation and the exchange of knowledge take place in new types of organisational constellations, such as networks and temporary projects or alliances, which can be positioned between the traditional firm and the spot market. In terms of management of these innovation processes and projects, which are human capital and knowledge-intensive types of activities, the emphasis turned mainly to social norms and pressures as the modes of organisational control (e.g. Child and McGrath, 2001). The relational governance posits that socially defined, norm-driven definitions of proper behaviour can substitute formalised definitions of these norms (Zenger *et al*., 2002; Dekker, 2004; Grandori, 2006). Trust is the social mechanism which governs behaviour, as it is expected that partners will not take advantage of each other or intentionally harm each other's interests (Bhattacharya *et al*., 1998; Jones and George, 1998; Hagen and Choe, 1998; Das and Teng, 1998) because of the value attached to the relationship (Bromiley and Cummings, 1992; Mayer, Davis and Schoorman, 1995). Trust develops in conditions of cognitive closeness (McEvily, Perrone and Zaheer, 2003) and acquaintance with the reliability (compliance trust) and competencies (competence trust) of a partner. This is the case when there is a frequent and high level of information exchange (Gulati, 1995; Caniëls and Gelderman, 2010).

In contrast to this predominant, relational view on governance of innovation in networks, there is also the structural perspective which posits that governance of collaborative constellations such as those in networks of actors is dominated by rational behaviour, which may entail opportunistic or self-interested actions. In order to safeguard against opportunistic behaviour, design of detailed contracts and agreements is considered as the remedy (Williamson, 1985; Poppo and Zenger, 2002). Structural governance mechanisms consist of rules, such as ownership

rights, that can be observed in written documents and include explicit incentives that are determined and implemented by formal authorities (Zenger, Lazzarini and Poppo, 2002). In the knowledge-intensive and knowledge-exchange innovation projects and processes, there is less reliance on structural forms of governance, such as authority, decision (or property) rights, order-giving, supervision and monitoring (Jones, 1983; Foss, 2007). The reason for this is that structural governance mechanisms are based on the norm of efficient organisation, which is difficult to establish in a context where transaction costs cannot be defined.

Contribution to research on governance in innovation partnerships

Due to the inability to define knowledge exchange in terms of transaction costs, the focus of literature has been on the relational governance mechanisms, paying little attention to the norm of efficient organisation. This gap in research can be tackled by greater attention to the definition of organisational challenges related to innovation and knowledge-exchange processes, and identification of the way in which interplay between structural and relational governance mechanisms can tackle these challenges to arrive at effective and efficient outcomes (Grandori, 1997; Osterloh and Frey, 2000; Foss, 2007). In addition to the relational form of governance, more focus should be put specifically on structural mechanisms, which are based on calculation and maximisation of benefits, and which can be steered and managed (e.g. reward systems, information systems) (Grandori, 2001; Gulati, 2007).

In order to be able to assess the efficient form of governance, the organisational challenges related to knowledge exchange need to be considered specifically. This can be done by dimensionalising knowledge. Previous research has done this by considering tacitness versus explicitness, complexity versus non-complexity (Winter, 1987) or level of novelty (Contractor and Ra, 2002). In the present research, uncertainty will be used to dimensionalise knowledge, because it can reflect the organisational challenges entailed in innovation. The extent to which knowledge about the innovation process and its outcome can be established at the start of the innovation project constitutes an indicator of the extent to which, and how difficult it will be to plan and organise the innovation process. For example, a large degree of uncertainty can lead to high organisation costs by increasing the time and resources (human and physical) needed to coordinate the process and make adaptations which are needed as a consequence of unforeseen developments. The greater the uncertainty (the more novel and complex the knowledge entailed in the innovation process), the greater the possibility for increased costs of integrating and creating new knowledge. The deployment of governance mechanisms should take into account the coordination costs and challenges of planning, sharing, integrating, and creating knowledge.

Another trait of knowledge which can increase coordination costs of innovation is knowledge heterogeneity. Partners with heterogeneous backgrounds and from different disciplines circulate in different flows of information (Burt, 2001) and have a lower level of similarity in their attributes, capabilities and expectations (Gulati, 1995), as well as lower levels of

shared understanding of professional conduct and technical and managerial standards (Sako, 2006). Actors from different disciplines and knowledge backgrounds can have more difficulty understanding each other and each other's contribution to the innovation process. This can lead to higher coordination costs as more effort may be needed to reach an alignment of ideas. The heterogeneity of interests, views and expertise can lead to conflict, opportunistic behaviour or immobility of knowledge and information (Omta and Van Rossum, 1999; Dyer and Singh, 1998) which also raises the costs of coordination to transfer knowledge. In order to contribute to the gap in research about structural governance in the context of innovation, (innovation) uncertainty and (network) heterogeneity are used in the present study as knowledge-exchange traits to assess the coordination costs and organisational challenges in co-innovation partnerships. Subsequently, it is explored how the interplay between structural and relational governance mechanisms can minimise costs and maximise benefits from co-innovation partnerships.

1.3.4 Overarching contribution of the thesis

Each of the separate parts of the research presented in this thesis have a specific contribution, as set out above. The overarching contribution of the study resides with the specification of the internal and external firm capabilities and governance mechanisms for innovation and knowledge integration and exchange to enhance innovation performance. The study improves the insight about the management of in-house innovation projects by examining how the determinants of in-house innovation performance impact upon each other. The study shows that next to functional capabilities, integrative capabilities have an important role in dealing with novelty and complexity and newness of the innovation to enhance product potential (superiority) of the innovation. In addition, the role of especially the organisational capabilities in external knowledge absorption is emphasised and studied, integrating the networking behaviour as one of the knowledge absorption organisational capabilities. Furthermore, in the context of co-innovation partnerships, the intertwined character of the structural and relational governance mechanisms is studied and it is demonstrated that structural governance also offers mechanisms which provide for the necessary flexibility in the context of innovation uncertainty.

1.4 Thesis setup

The first part of the current thesis focuses on the management of in-house innovation projects. The factors related to in-house innovation performance have been accumulated through the means of research such as the SAPHHO study (Rothwell, 1972) and Cooper's pivotal work developing the NewProd assessment tool (e.g. Cooper, 1979, 1987, 1999). These are considered as forerunners of an extensive number of studies which focused on a large number of independent variables which affect innovation project performance. These studies were largely performed in technology intensive fields, such as electronics or semi-conductors, where R&D and product development are central activities in the innovation processes. In case of the

agri-food sector, the food processing companies are most comparable to the companies on the basis of which these determinants of innovation project performance are compiled. Product development, but also the organisation of innovation in projects with cross-functional teams, is also to be found at the food processing companies. Therefore, the food processing companies are selected for the studies presented in Chapters 2 and 3, with the innovation project as the unit of analysis.

One of the problems with the current model of factors is the predominant focus on the direct relationship between a set of independent variables and success or failure of the innovation projects (Cooper, 1999; Lynn *et al*., 1999). The complexity and non-linearity of innovation processes indicates that there are more complicated relationships among the factors which affect innovation performance. With this as a starting point, in the study in Chapter 2, it was hypothesised and tested how the different factors affect each other and, eventually, the outcome of the innovation process. In order to contribute to the existing knowledge about the effect of the different determinants of innovation performance, Chapter 2 considers a path model where the relationships between innovation-related factors (i.e. novelty and newness to the firm) and functional and integrative capabilities (i.e. resources and communication) to innovation potential (i.e. product, market and project) and ultimately innovation performance are examined. This first part of the study helps managers to understand how different dimensions which are important for innovation performance affect one another, and where the managerial focus should be in order to manage the organisational challenges of innovation.

Research Question 1 (RQ1): *What are the relationships between innovation characteristics, functional and integrative capabilities, innovation potential and ultimately innovation performance?*

As mentioned, the compilation of factors to detect the potential strengths and weaknesses of innovation projects and determine their innovation potential and performance was mainly based on studies in technology-based fields, such as automotive, electronics, semi-conductors or pharmaceuticals. However, the context where the innovation is taking place may result in different requirements for the necessary managerial and organisational capacity of innovation processes. The food and beverages (F&B) companies differ from these technology-based fields in a number of ways. Unlike in the technology-based industries, such as consumer electronics, where the product generations follow-up each other with dazzling speed, in the F&B industry the end-consumers are perceived to be distrustful of radically new products and changes in consumption patterns (Sarkar and Costa, 2008). In addition to the wary customer, there are an additional number of aspects which distinguish the F&B from technology-based industry. For a long time, the main focus of large, multinational, food processor companies has been on enlarging production capacity and on cost reduction (Vanhaeverbeke, 2007; Duysters *et al*., 2006; Costa and Jongen, 2006; Senker and Managematin, 2008). The innovations were usually adopted from other industries and the R&D budgets of food processing companies, with

less than 5% of the entire budget, were relatively low compared to companies in technology-based industries (Christensen *et al*., 1996; Avermaete and Vianne, 2002; Wilkinson, 2002; Stewart-Knox and Mitchell, 2003; Galizzi and Venturini, 2008). Accordingly, the F&B industry is typically described as a relatively mature and slow-growing area of business, and quite conservative in the type of innovations it introduces into the market (Costa and Jongen, 2006). While technological developments are increasing the technological rate of the food processing industry (Geylani *et al*., 2008), the differences in conditions in technology-based and F&B industries are still present and may lead to different requirements in the management of innovation processes. In order to find out whether there is a difference in the importance of variables which affect innovation performance in the food-processing and technology-based industries, the question addressed in Chapter 3 is:

Research Question 2 (RQ2): *What are the differences between the food and beverages (F&B) and the technology-based industries as concerns the factors influencing innovation performance?*

In Chapters 4 and 5, the focus is on the exchange of knowledge and collaboration with external actors to innovate and enhance innovation performance. In order to understand how innovation performance of agri-food actors can be increased, the capacity of knowledge acquisition and absorption from the network is studied in Chapter 4. In order to analyse this relationship between the organisational capacities to absorb external knowledge, the unit of analysis in this part of the study is at the firm/individual level. In order to rule out the differences which exist among different chains, it has been decided to focus on the pig sector in particular. The pig sector is an important area of economic activity and has a long tradition in the Dutch agri-food industry, with a developed network of institutions. The development towards ever-increasing intensification in pig farming has sharpened the attention of societal and consumer organisations to innovation which safeguards animal welfare and pre-empts health risks from pork consumption. The need for increased innovativeness in this sector, especially among farmers as one of the most important chain links for the production of pork, and the potential of the network to contribute to its innovativeness, has been the basis for selecting pig farmers as the study object. The study in Chapter 4 reverts to the definition of absorptive capacity as '*a set of organizational routines and processes, by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability*' (Zahra and George, 2002, p. 186). In contrast to studies which regard organisational mechanisms as antecedents of absorptive capacity, the study in Chapter 4 addresses the dynamic organisational capability of absorptive capacity by studying the '*multidirectional and fluid path* (among the different dimensions of absorptive capacity)*, rather than a patterned* (sequential) *trajectory of knowledge acquisition* [to] *exploitation*' (Zahra and George, 2002, p. 198). By considering networking frequency (and range) as an organisational capability, networking behaviour is integrated into the definition of absorptive capacity as a dynamic capability. The research question addressed in Chapter 4 is:

Research Question 3 (RQ3): *What is the relationship between networking behaviour and absorption of external knowledge, and innovation and business performance?*

Chapter 5 focuses on the governance mechanisms in co-innovation partnerships with external actors to exchange knowledge and enhance innovation performance. Here, the unit of analysis is at the inter-organisational co-innovation partnership level. Long-term, sustainability-oriented innovation goals in the agri-food sector may require co-innovation with actors from the chain and the wider network of stakeholders. While such collaboration brings advantages for the outcome of the innovation process, it also brings additional organisational challenges. Next to the uncertainty which is inherent to innovation in general, collaboration with other firms and stakeholders can increase the coordination costs, due to increased information-processing requirements and the need for additional effort and coordination to align different interest and views. Eighteen agri-food co-innovation partnerships are selected for the study in Chapter 5. Due to their long-term-oriented innovation goals and network heterogeneity, these partnerships constitute the appropriate setting to study how the interplay between structural and relational governance mechanisms deals with the previously mentioned coordination costs and organisational challenges.

Previous research emphasised the importance of relational governance mechanisms in managing innovation and knowledge-exchange processes, because of the asserted inadequateness of structural governance in conditions of innovation. Structural governance, which is based on the norm of efficiency and effectiveness, is considered incongruent with the need for flexibility and explorative conditions in innovation processes. With the argument that structural governance can offer structure, but also flexibility, the aim of the present study is to address the lack of research attention to structural governance mechanisms (Foss, 2007) in conditions of innovation and knowledge exchange. The coordination costs and organisational challenges related to uncertainty (inherent to innovation) and network heterogeneity (inherent to co-innovation partnerships) are considered to explore how the interplay between structural and relational governance mechanisms can contribute to the minimisation of organisational challenges and maximisation of benefits of co-innovation. Accordingly, the study in Chapter 5 addresses the question:

Research Question 4 (RQ4): *How can the interplay between structural and relational governance mechanisms tackle the organisational challenges entailed in innovation uncertainty and network heterogeneity in co-innovation partnerships?*

The thesis ends with a conclusion which brings together the results from these four chapters, providing an overview of internal and external organisational capabilities and governance mechanisms which can lead to an improvement in innovation performance. The different perspectives employed to study the way in which innovation performance can be enhanced

put specific focus on the management of in-house innovation capabilities in Chapters 2 and 3, external interaction or networking behaviour and external knowledge absorption in Chapter 4, and structural and relational governance mechanisms in Chapter 5 (see Figure 1.2 for the overview). The results from this research are specifically relevant for actors from the agri-food sector. However, the research also contributes to theory by assessing the validity of (testing the existing) models for management of internal innovation projects, directly examining the relationship between networking and absorptive capacity as important determinants of innovativeness, and building further on the theory of governance of innovation (and knowledge) management.

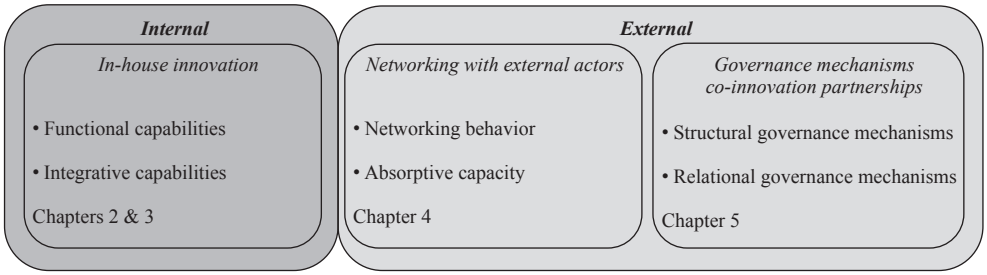

Figure 1.2 *Chapter overview.*

2. A path model of determinants for innovation project performance[2]

2.1 Introduction

As mentioned in the introduction, the first part of the present thesis focuses on the management of in-house innovation projects. Due to increased global competition, fast development of technologies and changing customer demands, firm performance is increasingly dependent on the continuous improvement and introduction of new products. As innovation is costly, time-consuming and characterised by many uncertainties, many studies delved into innovation success factors, starting with the SAPHHO study (Rothwell, 1972) and Cooper's pivotal work developing the NewProd assessment tool (e.g. Cooper, 1979, 1987, 1999). Despite the collection of a large number of factors which affect innovation performance, around 44% of the innovation projects still fail to achieve their profit targets (Cooper and Edgett, 2009). Only one product concept out of seven becomes a new product winner and half of all new product launches are late to the market (Cooper and Edgett, 2009). These results indicate persistent shortcomings in improving innovation processes. These shortcomings may be related to the predominant focus on the examination of the direct relationship between a collection of innovation performance determinants and success or failure of the innovation process (Cooper, 1999; Lynn *et al*., 1999). For example, previous research established a negative relationship between newness of the innovation project to the company and innovation project success (Cooper, 1979) without considering that project newness may affect innovation process quality negatively, lowering the speed of market introduction and in this way affect innovation project success negatively. In order to address the failure of the existing research to establish the complexity of relationships among the determinants of innovation performance, the study in Chapter 2 focuses on this by combining insights from innovation management literature and functional and integrative capabilities, which originate from the resource-based view. The following research question is addressed:

RQ1: *What are the relationships between innovation and functional and integrative capabilities and innovation potential and ultimately innovation performance?*

Partial Least Squares (PLS) modelling is used in the present study to build a path model and test the complexity of the relations among the different factors. The present study builds on the work of Cooper (1979, 1987) but following Hollander (2002), complements it with the assessment of integrative communication capabilities. It brings together project and firm factors and examines their joint impact on innovation performance. This study contributes to existing literature by reconsidering the existing model of direct effect between a large number of independent variables and innovation project performance. A path model is built where insight

[2] This study is based on a paper submitted to Management Research Review Special Issue: Strategic Directions for Innovation Management.

from previous studies is used to hypothesise on the relationships between innovation-related factors (i.e. novelty and newness to the firm) and organisational capabilities (i.e. functional and integrative, communication capabilities) with innovation potential (i.e. product, market and project) and ultimately innovation performance. These relationships are tested using information collected from nine multinational companies from 22 high (96 respondents) and 16 (93 respondents) low performing innovation projects. Insight into the complexity of relations among these factors can assist companies to become more alert about the way in which different factors affect innovation performance simultaneously, rather than sequentially.

In Section 2, a short overview of previous studies about determinants of innovation performance is provided. In Section 3, findings from previous studies are used to hypothesise on the expected relations among these innovation performance determinants. In Section 4, the methods of data collection are described, an overview of the measures is provided and the partial least squares method of analysis is introduced. In Section 5, the tested hypotheses are presented and discussed. In Section 6, the conclusions are discussed and a number of recommendations are provided.

2.2 Previous research and hypotheses

From the pivotal work of Cooper (1979) onwards, numerous empirical studies have been done in order to establish the success factors of innovation projects and processes. The large pool of factors are categorised by means of different reviews and meta-analyses, however a universally valid theoretical framework was not developed. One of the streams of research, as identified by Brown and Eisenhardt (1995), focuses on the importance of a broad range of factors which are related to the planning and execution proficiency of the innovation process and its separate phases/stages (Ernst, 2002). Determinants such as the understanding of users' needs, attention to the market, senior leadership, product advantages, market attractiveness (large and growing market, low overall intensity of competition), and internal organisation (in terms of pre-development planning, early cross-functional, customer, and supplier involvement, more resources, and better teamwork) are identified as the most important pointers for success. The argument is that a well-planned, well-implemented, and appropriately supported innovation project will be successful (Cooper, 1988, 1990; Cooper and Kleinschmidt, 1987, 1995, 1996; Barczak, 1995; De Brentani, 1989; Dwyer and Mellor, 1991; Maidique and Zirger, 1984; Rubenstein *et al*., 1976; Souder and Chakrabarti, 1978). A number of studies put a special focus on market research capabilities, involvement of the customer and proficiency in marketing and sales of products (Atuahene-Gima, 1995; Balbontin *et al*., 1999; De Brentani, 1989; Calantone and di Benedetto, 1988; Mishra and Kim and Lee, 1996; Parry and Song, 1994; Song and Parry, 1997; Souder *et al*., 1997; Utterback *et al*., 1976). Another stream of research put the focus on the depth, rather than the breadth of factors which affect the success of innovation projects. Taking into account the information-processing and the resource-based view, especially the organisational and communication aspects (e.g. integrative communication capabilities team members, high flows of information and adequateness of resources and

capabilities) were emphasised in this research. It is argued that highest performance is attained in teams with high internal communication (resulting in e.g. better definition of goals, workable plans and goal and task prioritisation), cross-functional combination of perspectives in highly interactive and iterative fashion and violation of routines. Information-processing emphasises that frequent and appropriately structured task communication (both internal and external) leads to more comprehensive and varied information flow to team members and higher performing development processes (Balbontin *et al*., 1999; Balachandra *et al*., 1996; Ebadi and Utterback, 1984; Rothwell *et al*., 1974; Rubenstein *et al*., 1976; Souder and Chakrabarti, 1978; Thamhain, 1990; Yap and Souder, 1994). The resource-based view complements this by emphasising that frequent communication leads to higher performing development processes by increasing the skills and resources (e.g. finance, personnel, equipment) available to the team. Cross-functional teams with high communication and the organisation of work according to the demands of the development task are considered important (Barczak, 1995; Griffin, 1997; Maidique and Zirger, 1984; Pinto and Pinto, 1990; Song *et al*., 1997; Song and Parry, 1997).

These previously identified independent variables, which explain innovation performance, can be divided into innovation-related factors (i.e. novelty and newness to the company), organisational capabilities (i.e. functional and integrative communication capabilities) and innovation potential (i.e. product and market potential). Previous research generally regarded innovation novelty and newness to the company as negatively related to innovation performance, and the organisational, as well as the innovation potential factors as positively related to innovation project performance. These direct relationships were mainly established on the basis of the analysis of differences between successful and failed projects (Atuahene-Gima, 1995; Balbontin *et al*., 1999; Calantone and di Benedetto, 1988; Calantone *et al*., 1997; Dwyer and Mellor, 1991; Griffin, 1997; Maidique and Zirger, 1984; Mishra, Kim and Lee, 1996; Parry and Song, 1994; Rothwell *et al*., 1974; Cooper and Kleinschmidt, 1993; Balboltin *et al*., 1999; Balachandra *et al*., 1996; Ebadi and Utterback, 1984; Yap and Souder, 1994). Also, different levels of success and their distinguishing characteristics were determined with the use of cluster analysis (Cooper, 1984; Cooper and Kleinschmidt, 1986, 1995, 1996). In the present paper, it is argued that the predominant focus on the direct relationships between these factors and innovation project performance constitutes a limitation to the understanding of the management of the complex and non-linear innovation processes. The latter can be understood better by studying the effect of innovation-related factors on the organisational/managerial-related and innovation potential factors and simultaneously the effect of organisational/managerial and innovation potential on innovation performance (see Figure 2.1). In this way, the previously identified independent variables are used to build a path model which provides more insight into the complexity of the innovation process. In the following paragraph, the expected (inter-)relationships are discussed in more detail and the specific hypotheses are formulated and presented in Figure 2.2.

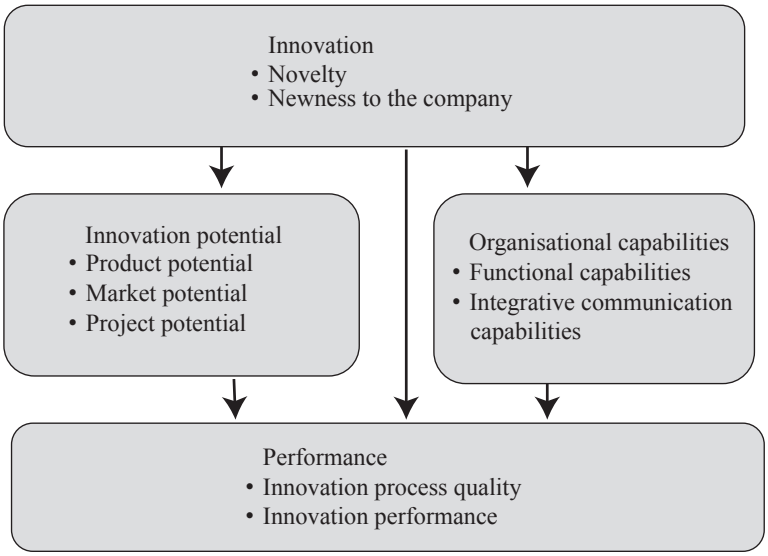

Figure 2.1 *Research framework.*

2.2.1 Hypotheses

Innovation includes the introduction of new products, successful commercialisation of new combinations, based on the application of new materials and components, the introduction of new processes, the opening of new markets or the introduction of new organisational forms (Schumpeter, 1934). Innovation entails inter-related processes including new idea conception, invention of a new device and the development of a new market in an integrated fashion (Myers and Marquis, 1969). The uncertainty entailed in innovation (Dhanaraj and Parkhe, 2006; Tatikonda and Rosenthal, 2000, Souder *et al*., 1998) makes it complicated for managers and innovation teams to guarantee a successful innovation outcome. One of the tools used is the stage gate model, where the innovation process is assessed at each of the innovation process stages, considering whether to stop, proceed or change the project. The downside is that the stage-gate assessment regards the innovation process in a sequential way, while it is a complex and non-linear process (Küppers and Pyka, 2002; Takeuchi and Nonaka, 1986). Activities which are part of different stages may be undertaken simultaneously and the goals of the different stages may not be achieved in a sequential order. For this reason, a model which portrays the complexity of different factors affecting the innovation performance might be more insightful and useful for the assessment of innovation projects.

Innovation novelty and project newness to the company are two of the aspects which are considered as uncertainty-enhancing factors in innovation processes. Products which are very novel and entail a high level of technology are usually more complex because they involve numerous units or components with multiple interactions and non-decomposability of parts

(Singh, 1997). Innovations which are mechanically or technically complex and which require technologies which are completely new to the company entail generally more challenging innovation tasks than less technologically complex innovations. Technologically complex innovations are also often more explorative in nature and create restricted ability to foresee whether the innovative idea will actually work. Novelty and technological complexity introduce a higher level of uncertainty with regards to the outcomes of each step in the development process. Due to the greater uncertainty, restrictions on planning possibilities emerge. Accordingly, unexpected adjustments to the project planning or innovation specifications may be needed later on in the innovation process. This can slow down the innovation project, leading to lower innovation process quality. Also, unexpected developments and changes may lead to the conclusion that the pool of especially the upstream functional capabilities is insufficient and requires adaptation. When the innovation project is technologically complex, it is more likely that the engineering skills of the staff of the company do not provide sufficient solutions to the problems encountered during the innovation process. Therefore, it is expected that novelty and complexity will be negatively related to upstream functional capabilities.

H1a: *Novelty of the innovation is negatively related to innovation process quality.*

H1b: *Novelty of the innovation is negatively related to adequateness of upstream functional capabilities.*

Newness of the innovation project to the firm is found to be negatively related to innovation project success by previous research (Cooper, 1979). Innovation newness to the firm is determined by the extent to which the customers, competitors, customer needs, the market, product (category) are new to the firm (Danneels and Kleinschmidt, 2001). For example, technological newness to the firm is based on the extent to which the technology needed for the engineering and design process, the production technology and production process are new to the firm. New products to the firm may enlarge the environment in which organisations operate and with which they are familiar (Normann (1971). This newness provides organisations with stimuli which they recognise less easily and for which they need time to adapt the existing channels of communication and fit with the existing cognitive structures (Danneels and Kleinschmidt, 2001). Innovation projects which are closer to the existing products, markets and technologies of the firm are more successful (Zirger and Maidique, 1990). The wider and greater the extent of newness of technology, product type or customers for the company, the higher the chance that the firm's upstream and downstream functional capabilities are not adequate for the innovation project to be executed as planned. Thus, in cases where an innovation project brings a new environment to which the firm has to adapt in terms of its understanding, resources and capabilities, it is expected that this new area of activities will cause difficulties until adjustment to the new situation is achieved. The resulting adaptation requirements are expected to have a negative impact upon the speed, planning, productivity and execution of the project. Accordingly, it is expected that the innovation process quality will be negatively affected.

H2a: *Project newness to the company is negatively related to upstream functional capabilities.*

H2b: *Project newness to the company is negatively related to downstream functional capabilities.*

H2c: *Project newness to the company is negatively related to innovation process quality.*

The information processing view posits that effective organisations are able to match their information-processing capacities (for gathering, transforming, storing, and communicating information) to the amount of uncertainty they face (Burns and Stalker, 1961; Lawrence and Lorsch, 1967; Galbraith, 1973; Duncan, 1973; Van de Ven *et al*., 1976; Tushman and Nadler, 1978). In very complex and uncertain conditions, direct contact between individuals, liaison roles, task forces, teams, goal-setting and planning at lower organisational levels are the appropriate mechanisms to assure a higher level of information processing (Tushman and Nadler, 1978; Van de Ven *et al*., 1976; Duncan, 1973). As already mentioned, previous research about product development found that team interaction, knowledge sharing and communication have a positive effect on the innovation process speed and efficiency (Imai *et al*., 1985; Katz, 1982; Zirger and Maidique, 1990; Brodbeck, 2001; Keller, 2001) as well as on innovation output in terms of the number of patents and amount of commercialised products (Allen, 1984; Visart, 1976). It has also been established that the clarity of objectives and feedback affect performance (Thamhain and Wilemon, 1987; Thamhain, 1996). As West and Anderson (1996) conclude, clear direction-setting enables focused development of ideas and assessment with greater precision. Thus, it can be expected that communication which creates clarity can contribute to execution of the innovation process with higher speed and efficiency, or in other words higher innovation process quality. Especially in the case of innovation, where non-routine and non-repetitive tasks are executed, frequent communication and effective information transmission is important for teams to acquire a comprehensive and complete understanding of complex, inter-related activities and enable informed decision-making (Hackman, 1990). Frequent communication enhances the absorptive capacity of the team members such that they become more efficient in gaining and using the circulating information (Brown and Eisenhardt, 1995). This increases the ability of the team members to understand each other's capacities and contributions to the innovation project. In complex, problem-solving projects, reflection on the objectives and processes is found to stimulate the individuals' understanding of tasks, leading to the proposal of alternative, novel and innovative approaches (Edmondson *et al*., 2001; West, 2000). The greater novelty and complexity in innovation projects, the greater the quantity and quality of information processing required to generate the necessary knowledge, complete the projects tasks and achieve the objectives, reduce the uncertainty and increase clarity, rationalising and ordering the process and avoiding errors (e.g. Cooper and Kleinschmidt, 1987; Hayes *et al*., 1988; Iansiti, 1992; Zirger and Maidique, 1990). This leads to the expectation that a higher level of novelty of the innovation project will create stimuli among the team members to increase their level of communication and information exchange to attain a higher level of problem-solving. Also newness of the innovation project to the firm is expected to create stimuli for team members to increase

their level of communication so as to create more clarity about the innovation tasks and steps needed to achieve the uncertain innovation goal.

H3a: *Integrative communication capabilities are positively related to innovation process quality.*

H3b: *Novelty of the innovation project is positively related to integrative communication capabilities.*

H3c: *Newness to the firm is positively related to integrative communication capabilities.*

Previous research concluded that one of the most important determinants of innovation project success is product advantage. A product with high potential offers advantages and is superior to the existing products. Added value can be manifested in terms of the product's cost savings, quality (Buzzell and Gale, 1987), performance advantages or a new combination of features (Zirger and Maidique, 1990). Products with high potential are able to meet customers' needs in a way in which the existing products fail. It is key to acquire insight into and understanding of the specific needs of the customers to be able to develop superior products which offer solutions or added value to customers, unavailable from the existing products (Utterback *et al.*, 1976; Cooper and Kleinschmidt, 1987). For this purpose, downstream functional capabilities are important. The sales force, the advertising and promotion, marketing and customer service skills and resources constitute the downstream functional capabilities which are important for the gathering of market information and development of the sales strategy. As the information and knowledge about customer preferences needs to be translated into new applications and developments, upstream functional capabilities such as the R&D, engineering and design, production and/or operation resources, people and facilities are also important to realise higher product potential. Upstream, technical and engineering capabilities of a firm are important for the creation of value to the customer in terms of higher quality, performance advantages, innovative features or cost-saving adaptations to the product. Therefore, it is expected that adequate upstream functional capabilities will have a positive effect on the product potential.

H4a: *Adequate downstream functional capabilities are positively related to product potential.*

H4b: *Adequate upstream functional capabilities are positively related to product potential.*

At the same time, cross-functional communication capabilities of the team members with different functional capabilities is essential for the combination of the information about the customer preferences and the knowledge and possibilities in terms of the design, development and production of the innovation. Communication among members in cross-functional teams is important to assure that integration takes place among the separate capabilities delivered by the engineering, production and marketing departments. Accordingly, communication is expected to increase the understanding about adequateness of upstream and downstream functional capabilities for cross-functional problem-solving in the innovation project. Through

enhanced cross-functional problem-solving, communication can help to increase the value and potential of the innovation/product, next to the increased adequateness of upstream and downstream functional capabilities.

H4c: *Integrative communication capabilities are positively related to upstream functional capabilities.*

H4d: *Integrative communication capabilities are positively related to downstream functional capabilities.*

H4e: *Integrative communication capabilities are positively related to product potential.*

Highly new and technologically complex innovations are usually designed to solve a complicated problem which is not easily solved by simple adaptations. Though novelty and technological complexity do not necessarily mean that a more superior product to the existing ones will be the result of the innovation project, it is often the case that highly innovative products which entail technological sophistication are able to offer some new and unprecedented solutions to the customers' problems. Because highly innovative and technologically complex innovations are expected to offer superior solutions to the customer which existing products are not able to offer, it is expected that:

H4f: *Novelty of the innovation is positively related to product potential.*

Market potential is defined as the potential demand for a new product in the target market (Narver and Slater, 1990; Song and Parry, 1997; Im and Workman, 2004). It is one of the descriptors of the market environment. Previous research by Cooper (1979, 1980) concluded that market size, growth rate, and product need constitute important factors for success in new product development (Cooper and Kleinschmidt, 1987). Products with unique benefits to customers, high quality, attractive cost, and innovative features are considered superior to competing products, as they have the ability to solve problems which the customers face. As products, which are superior to the existing ones, often include features which are valuable to the consumer, a positive relationship is expected between product superiority/potential and market potential. If a superior product has been based on market research and the wishes and needs of the customers, it is expected to be tailored to customer needs, lead to a growing market and/or offer opportunities in terms of marketing the product in multiple styles or different price ranges. Adequate downstream functional capabilities enable the innovation team to sense opportunities and threats and make timely and market-oriented decisions. Information about market opportunities and competitors' actions, as well as skills to market and sell the new product, are expected to increase the market potential of the innovation. Therefore, the following is expected:

H5a: *Product potential is positively related to the market potential of the innovation.*

H5b: *Adequate downstream functional capabilities are positively related to market potential.*

A great need for a product and/or a growing market is expected to create a stimulus for the project management team to put the emphasis on the completion of the project according to the specifications and within the defined schedule and budget. This increases the chance that the company can introduce the innovation/product to the market before its competitors. Accordingly, it is expected that market potential will be positively related to innovation process quality. A great need for the product among the customers and a growing market also increase the chance that the project will benefit end-users directly, that the innovation/product will result in high return on investment or that spin-off projects will follow. Such innovations are denoted, in the present paper, as innovations with a large project potential. In line with the finding by Im and Workman (2004) that financial performance, in terms of return on investment and profitability, is influenced by market potential of the product, the following is expected:

H5c: *Market potential is positively related to innovation process quality.*

H5d: *Market potential is positively related to project potential.*

Next to market size, market growth rate and product need (Cooper, 1979) as important determinants of the performance of new product introductions in the market (Cooper and Kleinschmidt, 1987), the presence or absence of strong competition is also identified as a determinant, because new product introduction strategies are strongly dependent on the match with the possibilities offered by the market. The conditions and business climate of the market are defined by for example the intensity of competition in the market. The presence of one strong competitor or too many competitors increases the struggle for customers (Edelstein, 1992; Iansiti, 1995). Frequent new product introductions by the competitors also make it more difficult to capture a part of the market. Accordingly, it is expected that in case of high market competition, it is more difficult to introduce an innovation/product for which there is a great need among customers or for which the market is growing very quickly. Therefore, a negative relationship between market competition and market potential could be expected.

H5e: *Market competition is negatively related to market potential.*

Previous research used different measures to establish the success of innovation projects. According to Brown and Eisenhardt (1995) there are different groups of indicators measuring innovation performance. One of these is related to financial success of the innovation (project) expressed in terms of profit, sales, payback or market share. Another set of measures is related to operational and process success or productivity, speed of product development and project execution within the set budget and schedule. In the present study, performance is measured on the basis of two measures. One of these measures is innovation process quality, which measures the extent to which the project is executed within budget and according to the

schedule and initially set specifications. The other measure is innovation performance. The latter is established on the basis of the indication whether the innovation market introduction resulted in substantial sales for the company, or whether the project either terminated before market introduction or proved to be a failure in the market.

Innovation projects with high innovation process quality are advantageous because they decrease the amount of time to product launch and allow product introduction before competitors. Therefore, it is expected that projects with high innovation process quality will increase the chance of companies to capture a (larger) part of the market and result in higher profits. Innovations which are considered to have a high probability of creating direct benefits to the end-users, leading to spin-off innovation projects and generating profit for the company, are expected to perform well after market introduction and actually create profit for the company. This expectation is based on the assumption that innovators are able to provide a realistic assessment of the opportunities in the market and the need for the innovation/product among their (potential) customers.

H6a: *Innovation process quality is positively related to project potential.*

H6b: *Innovation process quality is positively related to innovation performance.*

H6c: *Project potential is positively related to innovation performance.*

Figure 2.2 provides an overview of the hypothesised relationships.

2.3 Data and methods

Data were collected from 9 multi-national companies, from different industries. The number of employees per company ranged between 1,300 and 50,000 and 2010 turnover ranged from 0.4 to 8.2 billion euro (see Table 2.1). Eight of the companies are headquartered in the Netherlands and one in France. The activities of these companies range from agri(-food) production and processing, provision of utility services, to the production of high-tech precision products for businesses.

The data are collected in 38 projects (approximately 5 projects per company) and the questionnaires were completed by 189 project team members (on average 3 to 4 team members per project), including engineers, marketing and sales, and procurement staff. Twenty two projects (96 respondents) were successful in the market, while 16 projects (93 respondents) turned out to be a failure in the market place.

In each of the participating companies contact was established with the head of the R&D/innovation department, or the project manager which dealt with innovation in the company. Together with the innovation/R&D manager, a number of successful and failed innovation

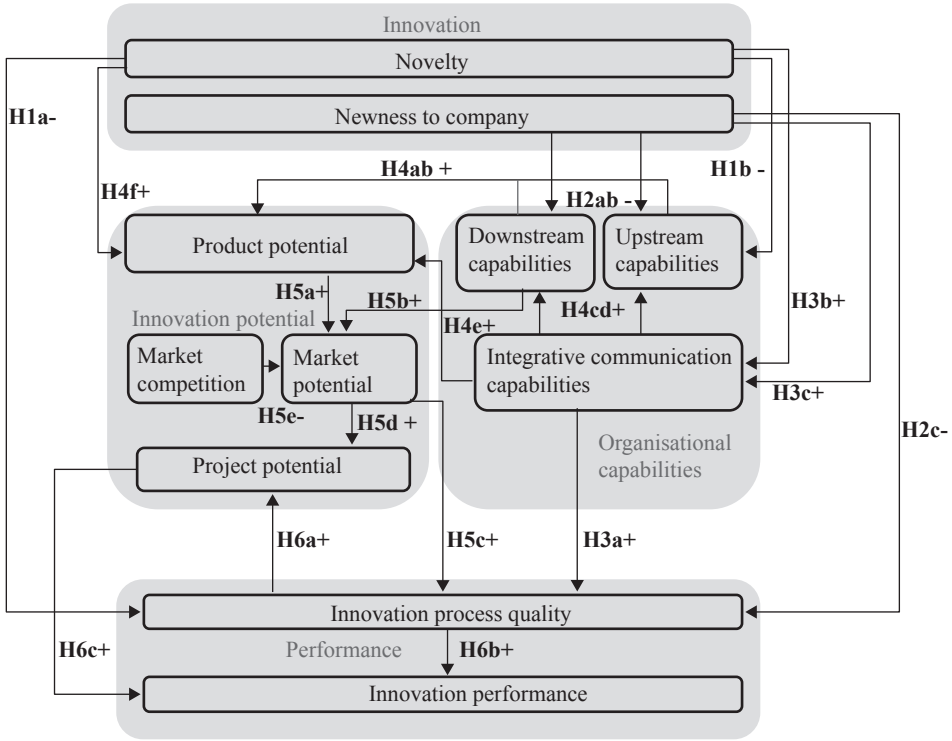

Figure 2.2 *Conceptual model.*
+ positive expected relationships; – negative expected relationships.

Table 2.1 *Summary company details.*

Number of companies	Average (range) turnover (billion euro)	Average (range) employees (1000)
5	1.6 (0.4-3.5)	8.0 (1.3-16)
4	6.2 (4.0-8.2)	33.8 (20-50)

projects were selected. Per project, a questionnaire was completed with general questions about the company profile, the cooperation and sources of information relevant for the project. The questionnaire builds on the NewProd innovation assessment tool (Cooper, 1979) and combines it with questions about communication capabilities of the innovation team, as developed by Hollander (2002) in Genesis (a follow-up to NewProd). The questionnaire contains thirty-six 10-point Likert scale questions about perceptions of the innovation team members about novelty, project newness to the firm, upstream and downstream functional capabilities,

integrative communication capabilities, innovation potential, innovation process quality and market competition. The respondents were asked to indicate to what extent they completely disagree (1) or completely agree (10) with the statements (see Table 2.2 for an overview).

Table 2.2 *Measurement model N=189; all items are significant at p<0.01.*

Construct	Item	λ
Novelty	1. Our product is highly innovative and totally new to the market.	0.95
CR = 0.84	2. Our product is a very high-technology one.	0.89
AVE = 0.65	3. Our product is mechanically and/or technically very complex.	0.55
Newness to the	4. The nature of the production process is new to our company.	0.83
company	5. The technology required for development of the product is new to	0.77
CR = 0.81	our company.	
AVE = 0.48	6. The distribution system and/or type of sales force for this product is	0.76
	totally new to our company.	
	7. The product type is totally new for our company.	0.49
	8. The potential customers for this product are totally new for the	0.47
	company.	
Integrative	9. If I doubt the opinion of a team member I will definitely confront this	0.79
communication	member with it.	
capabilities	10. I completely understand the potential problems of the project.	0.78
CR = 0.86	11. The performance requirements for this project are clear to me.	0.77
AVE = 0.60	12. I have enough communication with my team members to do my	0.75
	work efficiently and in an effective way.	
Upstream functional	13. Our engineering skills and people are more than adequate for this	0.85
capabilities	project.	
CR = 0.86	14. Our production resources or skills are more than adequate for this	0.79
AVE = 0.61	project.	
	15. Our management skills are more than adequate for this project.	0.77
	16. Our financial resources are more than adequate for this project.	0.72
Downstream	17. Our sales and/or distribution resources and skills are more than	0.89
functional capabilities	adequate for this project.	
CR = 0.89	18. Our advertising and promotion resources and skills are more than	0.85
AVE = 0.73	adequate for this project.	
	19. Our marketing research skills and people are more than adequate for	0.82
	this project.	

Table 2.2 *Continued.*

Construct	Item	λ
Product potential CR = 0.91 AVE = 0.71	20. Compared to competitive products, our product will offer a number of unique features or attributes to the customer.	0.89
	21. Our product will be of higher quality than competing products.	0.87
	22. Our product will be clearly superior to competing products in terms of meeting customers' needs.	0.87
	23. Our product will permit the customer to do a job he/she cannot presently do with what is available.	0.71
Market potential CR = 0.87 AVE = 0.57	24. Potential customers have a great need for this type of product.	0.82
	25. This project will contribute to the competitive advantage of the company.	0.81
	26. The customer will definitely use the product.	0.74
	27. This product has a high potential, i.e. additional products, multiple styles, price ranges.	0.71
	28. The market for this product is growing very quickly.	0.68
Market competition CR = 0.87 AVE = 0.62	29. There are many competitors in this market.	0.90
	30. The market is highly competitive.	0.79
	31. There are frequent new product introductions by competitors in this market.	0.74
	32. There is one strong competitor in this market.	0.71
Project potential CR = 0.79 AVE = 0.55	33. The probability that this project will earn more money for the company than it costs is very high.	0.77
	34. The probability that this project will have a spin-off effect, such as development of a new generation of products, is very high.	0.74
	35. The probability that this project will directly benefit the end-user, either through increasing efficiency or effectiveness, is very high.	0.72
Innovation process quality CR = 0.80 AVE = 0.58	36. This project fulfils all its objectives/meets the specifications.	0.79
	37. This project will be completed within the original budget.	0.78
	38. This project will be completed within the original schedule.	0.71
Innovation performance	Successful projects are defined as projects that are not only a success in terms of engineering/technological accomplishment, but also perform well after market introduction and generate substantial sales for the company. Failed projects are projects that are either stopped before project completion or market introduction, or prove to be a failure in the market.	

The analysis of the data consisted of the estimation of a path diagram using the partial least squares (PLS) technique for latent path model estimation (Wold, 1982). For the establishment of the relationships among the different factors in our model, PLS offers a number of advantages over the more frequently-used techniques such as multiple regression. With the use of PLS, relationships among the latent variables are estimated and tested in the context of a measurement model, taking into account the measurement errors in the observable variables. PLS offers the possibility to iteratively make adaptations in the factor structure and establish the effect of these on the relationships among the latent variables, which enables optimisation of the model. Furthermore, PLS uses the bootstrap procedure to calculate the standard deviation and an approximation of the t-statistic. This overcomes the lack of formal significance tests for estimated parameters in case of nonparametric methods (Chin, 1998).

2.4 Results

In the following part, the expected relationships among the factors which affect innovation performance will be discussed on the basis of the empirical analyses. The path coefficients, indicating the strength of the relationships, and significance levels presented in Table A1.2 in Appendix 1 and Figure 2.3 are used to discuss the results. The measurement model, presented in Table 2.2, provides an overview of the variables and constructs which are used to measure the concepts in our model. In addition to the factor loadings per item, the composite reliability and the average variance extracted per construct is also presented in the table. Figure 2.3 gives a visual overview of the relations among the concepts as identified on the basis of the PLS analysis. The figure presents the path coefficients and the R^2 (the proportion of variability in a data set that is accounted for by the statistical model). Table 3.1 in Chapter 3, Section 3.5 provides an overview of the correlation coefficients among the constructs in our model.

2.4.1 Variables and model validity

The measurement model, in Table 2.2, shows that most of the loadings for the multiple-item constructs are positive and higher than the 0.7 criterion which indicates convergence of the indicators with their responding underlying constructs. There is an exception to this criterion in the case of a number of indicators (items 3, 7, 8 and 28 in Table 2.2). This exception is made because of theoretical considerations (the items remain conceptually important descriptors of the constructs, despite their loading deviation from the criterion). The convergent reliability of the constructs, indicated by the average variance extracted (AVE), is above (or very close to) the critical value of 0.5 (Fornell and Larcker, 1981; Henseler *et al*., 2009). In the case of the construct Newness of the project to the company, the AVE of 0.48 almost reaches the critical value of 0.05 and is therefore retained in the analysis. The average variance extracted indicates that the constructs explain at least 50% of the variance in the observed measures. The composite reliability of all constructs reaches the critical value of 0.8 (Fornell and Larcker, 1981; Henseler *et al*., 2009).

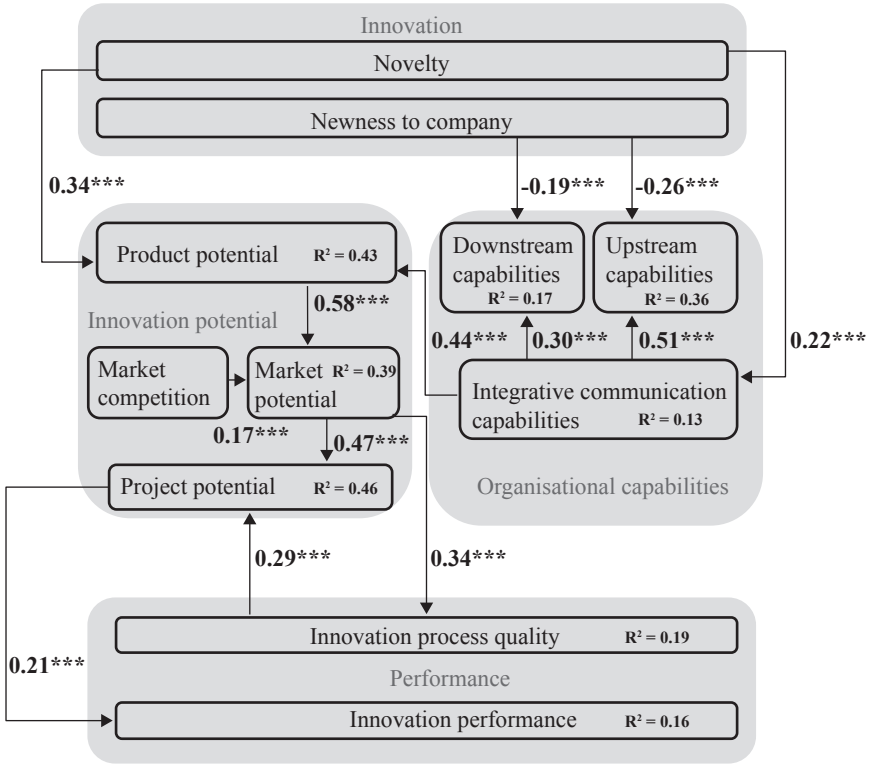

Figure 2.3 *Structural model; *** p<0.01.*
– negative relationships.

Discriminant validity is achieved as each construct has a higher correlation with its measures than with any other construct (i.e. the square root of the AVE). The structural model is considered appropriate when a significant portion of the variance in the dependent variable is explained by the independent variables (Fornell and Larcker, 1981; Henseler *et al*., 2009). The R^2s between 0.30 and 0.50 indicate that a considerable portion of variance is explained by their predictor variables. The variable where the explained variance by the independent variables is around 20% is also acceptable (Fornell and Larcker, 1981; Henseler *et al*., 2009). Figure 2.3 provides an overview of relations which are significant at the p-value of 0.01. In combination with the acceptable R^2 scores, it can be concluded that the model is appropriate (Fornell and Larcker, 1981; Henseler *et al*., 2009). The size of the company (number of employees), the type of sector and the number of respondents per project are included in the model as control variables. A significant relationship is established between the control variables and a number of independent and dependent variables[3].

[3] An overview of these relations is available and can be accessed upon request to the author.

2.4.2 Structural model

Novelty and complexity of the innovation project was expected to be negatively related to the adequateness of upstream functional capabilities for the project, because unexpected changes and developments may require different capabilities, resources and skills than possessed by the research and development of the company. However, this hypothesis is rejected, as no significant relationship was found here (see Figure 2.3). Also the hypothesis that novelty and complexity of the innovation project would negatively affect innovation process quality is rejected (see Figure 2.3). The data does not confirm that highly novel, technologically complex and intensive projects cause delays and require adaptations in the project budget, planning or specifications of the innovation.

The hypotheses that the newness of the innovation project to the company would have a negative effect on the adequateness of upstream and downstream functional capabilities are confirmed by the significantly negative relationships (see Figure 2.3). While innovation novelty seems not to be related to adequateness of firm capabilities, newness of the innovation project to the company does seem to create challenges for the company capabilities and resources. The significantly lower adequateness of the upstream and downstream functional capabilities in the case of high project newness indicates that a company needs a higher level of flexibility and adaptation when it engages in a completely new innovation. In contrast to the expectation that project newness would create obstructions to the planning, budget or specifications of the innovation project, no significant relationship was found between project newness and innovation process quality.

As expected, a significantly positive relationship is found between novelty and complexity of the innovation project and integrative communication capabilities (see Figure 2.3). A high level of novelty and complexity of the project stimulates the team members involved in the project to exchange more information to increase the understanding of the problems in the project, clarify the performance requirements and execute the project in an effective and efficient way. While taking this finding into account, it is remarkable that no significant relationship was found between integrative communication capabilities and innovation process quality. If communication capabilities are higher in case of high novelty and complexity, it would be expected that these advanced communication capabilities have a positive effect on execution of the project within budget and according to planning and specifications. However, this does not seem to be the case. The integrative communication capabilities do not turn out to contribute to a higher process quality. The integrative communication capabilities do contribute to a higher level of adequateness of upstream and downstream functional capabilities (see Figure 2.3). This indicates the importance of communication in order to understand how the different capabilities can be used and combined to solve problems and generate the necessary and inventive solutions. When integrative communication capabilities are at work, upstream and downstream functional capabilities are evaluated as more adequate for the innovation project. The stronger relationship between communication capabilities and upstream,

rather than downstream functional capabilities indicates that intensive communication can contribute significantly to the understanding about the problem-solving at the technology side. Communication among the researchers and developers of the innovation is important for resolving problems related to the development of the product. Missing market knowledge is more difficult to compensate by more intensive communication. The adequateness of these functional capabilities is perhaps more easily upgraded by additional employees with more or better skills in sales and advertising.

As expected, novelty and complexity of the innovation has a positive relationship to product potential (see Figure 2.3). Novel and complex innovations lead to more unique, superior and qualitative products. In contrast to the expectation that upstream and downstream functional capabilities would be positively related to product potential, as adequate functional capabilities can increase the quality and superiority of the product, it is mainly the communication capabilities which increase understanding and problem solving, and with this the superiority and quality of the innovation. Only a positively significant relationship was found between the integrative communication capabilities and product potential (see Figure 2.3). It may be concluded that due to its important role in the effective combination of upstream and downstream functional capabilities, integrative communication capabilities constitute a strong determinant of product potential.

Also as expected, a significantly positive relationship is found between product potential and market potential (see Figure 2.3). Products which offer unique features or higher quality to the customer have a higher potential in the market to be used and bought by customers. For this kind of product a growing market and applicability in additional products, multiple styles and price ranges can be expected. As expected, products with high level of usability by customers and multiple application possibilities are more inclined to benefit end-users, generate profit and spin-offs for the company. This is reflected by the significantly positive relationship between market and project potential (see Figure 2.3). The expectation that especially downstream functional capabilities would play an important role in the raising of the market potential of the innovation is not confirmed. Apparently, the marketing and sales skills and efforts cannot raise the market potential of innovation to the extent that the innovation novelty and product potential can.

Strong market competition, in terms of the presence of one strong or many competitors and frequent new product introductions was expected to have a negative effect on innovation market potential. However, the results show a positive relationship between market competition and market potential (see Figure 2.3). It turns out that strong market competition stimulates innovators to find gaps in the market and create products for which there is a great need among the customers, or products which have high applicability to additional products, multiple styles and price ranges so as to be able to provide diversification to the customer. Higher competition in the market stimulates companies to be more innovative in their effort to raise the market potential of their innovation.

The expectation that innovation process quality has a positive effect on the project potential is confirmed (see Figure 2.3). When the project is executed within budget and according to the schedule and specifications, there is a greater expectation that the innovation will benefit end-users and generate spin-off and profits for the firm. As expected, a significantly positive relationship is found between market potential and innovation process quality (see Figure 2.3). This indicates that in projects with high market potential and the prospect of high value generation for the company, emphasis is placed on a rapid and effective process of development in order to reduce the time-to-market and introduce the product to the market before competitors. However, innovation process quality does not seem to have a significant effect on the performance of the innovation after market introduction. Project potential does have a positive effect on innovation performance (see Figure 2.3), indicating that the positive expectation of the team members about the potential of the project often proves to be correct.

An overview of all hypotheses can be found in Table 2.3.

2.5 Discussion and conclusions

While previous research identified factors such as novelty, newness to the firm, functional capabilities, integrative communication capabilities and innovation potential as determinants of innovation project performance, the question remained how these variables affect one another. Therefore, in the present paper a PLS path model is built to increase understanding about the inter-relations between innovation-related and organisational/managerial factors with innovation potential and ultimately innovation performance. This can help companies to improve the management of their innovation processes and the performance of innovation projects. The results from our research demonstrate that the interrelations among these factors are indeed complex and go beyond only the direct relationships between a set of independent variables and innovation performance. The present research results in a number of conclusions which will be discussed here.

The novelty of the innovation to the market is an enabling factor which contributes positively to the product potential and with this to the market potential of the innovation. The complexity entailed in the novelty of the innovation entices communication among the innovation team members. Advanced communication capabilities of the innovation team members help them to learn from each other and upgrade their mutual understanding. This is in line with findings from previous studies which concluded that team interaction, knowledge sharing and communication affect the innovation process positively (Imai *et al*., 1985; Katz, 1982; Zirger and Maidique, 1990; Brodbeck, 2001; Keller, 2001). Frequent communication and effective information transmission enables comprehensive and complete understanding of complex inter-related activities (Hackman, 1990) and enhances mutual understanding among the team members in such a way that they become more efficient in gaining and using the information exchanged (Brown and Eisenhardt, 1995). As it turns out that novelty has a

Table 2.3 *Overview of not rejected and rejected hypotheses.*

Hypothesis 1	
a: Novelty and complexity of innovation is negatively related to innovation process quality.	Rejected
b: Novelty of innovation is negatively related to upstream functional capabilities.	Rejected
Hypothesis 2	
a: Project newness to the company is negatively related to upstream functional capabilities.	Not rejected
b: Project newness to the company is negatively related to downstream functional capabilities.	Not rejected
c: Project newness to the company is negatively related to innovation process quality.	Rejected
Hypothesis 3	
a: Integrative communication capabilities are positively related to innovation process quality.	Rejected
b: Novelty is positively related to integrative communication capabilities.	Not rejected
Hypothesis 4	
a: Adequate downstream functional capabilities are positively related to product potential.	Rejected
b: Adequate upstream functional capabilities are positively related to product potential.	Rejected
c: Integrative communication capabilities are positively related to upstream functional capabilities.	Not rejected
d: Integrative communication capabilities are positively related to downstream functional capabilities.	Not rejected
e: Integrative communication capabilities are positively related to product potential.	Not rejected
f: Novelty is positively related to product potential.	Not rejected
Hypothesis 5	
a: Product potential is positively related to the market potential of the innovation.	Not rejected
b: Adequate downstream functional capabilities positively related to market potential.	Rejected
c: Market potential is positively related to innovation process quality.	Not rejected
d. Market potential is positively related to project potential.	Not rejected
e: Market competition is negatively related to market potential.	Rejected
Hypothesis 6	
a: Innovation process quality is positively related to project potential.	Not rejected
b: Innovation process quality is positively related to innovation performance.	Rejected
c: Project potential is positively related to innovation performance.	Not rejected

mainly positive effect on innovation, managers of innovation processes should not evade it, despite its complexity.

In contrast to novelty, newness of the innovation project to the company does have a constraining effect on the innovation process. This is in accordance with previous findings that project newness requires specific managerial attention in order to mitigate its negative effect on innovation performance (Cooper, 1979; Zirger and Maidique, 1990; Iansiti, 1995; McDonough, 1993; Utterback, 1994; Gupta and Wilemon, 1990; Wheelwright and Clark, 1992). Newness has a negative relationship with adequateness of both the upstream and downstream functional capabilities for the innovation project. However, it can be concluded that integrative communication capabilities can have an important balancing effect, as they contribute to assurance of adequateness of functional capabilities. Especially in projects with a high level of newness to the company, learning and enhancement of existing functional capabilities is required. Communication capabilities can mitigate the negative effect of project newness on the adequateness of the firm functional capabilities by addressing the shortcomings of the existing pool of functional capabilities and resources, through learning and an increase in understanding. In order to ensure that knowledge about the market and customer needs is incorporated into the initial phases of research, design and development, cross-functional team collaboration and integration of upstream (design and production) and downstream (marketing and sales) capabilities is essential. Integrative communication capabilities play the most important role in this process because they facilitate the conversion of the knowledge, which is brought together through cross-functional integration. Innovation projects which are very new to the company create a new environment to which the firm has to adapt (Danneels and Kleinschmidt, 2001). Therefore, newness requires time and effort of the project team members to adapt their communication systems and increase the understanding about the problem-solving about the innovation. The negative effect of newness on the adequateness of capabilities and the need for stimulation of communication among innovation team members to offset this negative effect should be taken into account by managers.

With novelty and integrative communication capabilities as positive determinants, market competition and product potential have a positive effect on the market potential of the innovation. Strong competition in the market turns out to stimulate companies to be more innovative in their innovation process to generate products which can out-compete the others in the market. Product, market and project potential constitute important elements in the entire set of innovation performance determinants. Products which offer unique benefits to the customer, in terms of improved product quality and reduced costs, are more successful in the market (Zirger and Maidique, 1990; Utterback, 1971, Rubenstein *et al*., 1976, Cooper, 1975, 1983). Also, a product that is introduced in response to a growing market has a greater chance of success, because the existing players in the market may not be able to meet the market demand at the quality and reliability levels which are preferred by customers. This opens the door for innovative firms to capture profits from focus on quality and/or reliability.

Market potential of the innovation stimulates higher project potential directly and indirectly, through a positive effect on innovation process quality. Market potential creates a higher probability for profit from the innovation, creating a direct benefit for the end-users and spin-off projects for the company. At the same time, it creates an urge to reduce the time-to-market to be able to introduce the innovation to the market before the competitors do, increasing its market share and return on investment. Innovations with a high market potential create high expectations among the managers in terms of its potential to increase the profits and competitiveness of the firm. This alarms the managers to assign a high level of attention to an efficient and rapid innovation process, so as to assure that the innovation is introduced to the market before that of its competitors. It is not a rigid application of plans and objectives, but the capability to plan in such a way so as to reduce the chance that the goals need to be changed during the innovation process which is most important for innovation process quality (Dvir and Lechler, 2004). Innovation process quality does not directly affect innovation performance, but has a positive effect on project potential. This implies that preparation and planning have a positive effect on the probability that the innovation will benefit end-users, generate higher profits for the company and create spin-off effects, such as applications in other products or the development of a new generation of products.

2.5.1 Suggestions for further research

The current research advanced the stage of development of previous research which focused on the direct relationship between a set of independent variables and innovation performance. Instead of the models which reflect the importance of each factor for the performance of the innovation project, our model reflects the (inter-)relationships among the different determinants of performance and the effect of these complex relations on the innovation performance. The current research points to a number of findings such as the significant role of integrative communication capabilities for the adequateness of functional capabilities for the innovation project and for the product potential (superiority) of the innovation. While this finding indicates the importance of integrative communication capabilities for the innovation project performance, it also points to the important role of dynamics in innovation processes and the need for further research about the dynamics or interplay between integrative communication capabilities, functional capabilities and product potential throughout the innovation process.

2.5.2 Overview of conclusions and recommendations

- Novelty of innovation projects increases the product potential and with this the chance of a successful product launch on the market.
- The complexity that relates to innovation novelty induces innovation team integrative communication capabilities.
- Frequent communication, in very complex innovation projects and especially among the research and development team members, is important for problem-solving.

- The negative effect of innovation newness to the company on the adequateness of functional capabilities can be mitigated by emphasis on communication and learning among the innovation team members, but also by management through the provision of additional (financial) resources, training or hiring of new employees.
- Especially in highly competitive markets, high innovation potential creates an extra stimulus for managers to put emphasis on a rapid and efficient innovation process to introduce the innovative product to the market before the competitors.

3. Innovation capabilities in food and beverages vs technology-based projects[4]

3.1 Introduction

In the case of the food and beverages (F&B) industry too, performance has become increasingly dependent on continued improvement and the introduction of new products and processes. Consumers in the F&B industry demand unique flavours, convenience cooking and health-enhancing foods and diets tailored to their individual needs and preferences (Costa *et al*., 2001, 2007). The changes in the nature of both food demand and supply and the increasing level of competition make innovation not only an unavoidable corporate activity, but also one that is increasingly vital for overall agribusiness profitability (Sarkar and Costa, 2008). Innovations entailing and/or adopting innovative technological solutions (Sarkar and Costa, 2008) are promising in this respect. For example, biotechnological solutions have the potential to lead to the production of food with improved quality and nutritional content (Senker and Managematin, 2008).

However, unlike in the technology-based industries, where the product generations follow each other up with dazzling speed, in the F&B industry the end-consumers are perceived to be distrustful of radically new products and changes in consumption patterns (Sarkar and Costa, 2008). This has led the F&B industry to become highly selective in making use of technological possibilities for innovation (Senker and Managematin, 2008). In addition to the wary customer, there are an additional number of aspects which distinguish the F&B from technology-based industry. For a long time, the main focus of large, multinational, food processing companies has been on enlarging production capacity and cost reduction (Vanhaeverbeke, 2007; Duysters *et al*., 2006; Costa and Jongen, 2006; Senker and Managematin, 2008). The innovations were usually adopted from other industries and with less than 5% of the entire budget, the F&B processing companies' research and development (R&D) budgets are relatively low compared to companies in technology-based industries (Christensen *et al*., 1996; Avermaete and Vianne, 2002; Wilkinson, 2002; Stewart-Knox and Mitchell, 2003; Galizzi and Venturini, 2008). Accordingly, the F&B industry is typically described as a relatively mature and slow-growing area of business, quite conservative in the type of innovations it introduces into the market (Costa and Jongen, 2006). With emerging technologies, such as genomics and nanotechnology, innovation in the F&B industry has gradually become more and more radical. Despite difficulties such as protection of recipe-secrecy and intellectual property rights in the food industry, the technological rate of the food processing industry innovation is increasing (Geylani *et al*., 2008) through biotechnological (Phillips, 2002) and genomics/proteomics developments and techniques such as genetic mapping, minimal processing techniques, high pressure and cold pasteurisation.

[4] This study is based on a paper which is provisionally accepted for publication in the British Food Journal.

As mentioned in the introduction, the compilation of factors to detect the potential strengths and weaknesses of innovation projects and determine their innovation potential was mainly based on studies in technology-based fields, such as automotive, electronics, semi-conductors or pharmaceuticals. However, the context in which the innovation is taking place may result in different requirements of the managerial and organisational capacity of firms. In order to find out whether there is difference in importance of variables which affect innovation performance, in the F&B and technology-based industries, the question addressed in Chapter 3 is:

RQ2: *What are the differences between the food and beverages (F&B) and the technology-based industries as concerns the factors influencing innovation performance?*

Next to the examination of the generalisability of Cooper's NewProd model (1979, 1999) and the extensions of this model (Hollander, 2002), the present study also contributes to existing literature by exploring how the Cooper's NewProd model factors fit into the conceptualisation of innovation capabilities. It will be determined how the perceptions of team members about functional upstream and downstream capabilities, communication capabilities, novelty, project newness to the company, innovation potential, market competition and innovation process quality relate to the innovation performance of the project in terms of success or failure in the market – and whether these factors can be used as predictors for project innovation performance.

In Section 3.2, innovation is defined and the (model containing the) different critical success factors for innovations projects will be explained. In Section 3.3, a description of the differences between the F&B and technology-based industries is set out. Subsequent to Section 3.4, which describes the methodology of data collection and analysis, Section 3.5 provides an overview of the results from the logistic regression analysis. In Section 3.6, next to the differences in the innovation success factors in the F&B and technology-based companies, the implications and recommendations for the F&B companies are also discussed.

3.2 Theoretical background

3.2.1 Innovation

Innovation is a process of creative destruction, where the quest for profits pushes companies to innovate constantly, by breaking old rules to establish new ones (Schumpeter, 1934). This implies the introduction of new products and successful commercialisation of new combinations, based on the application of new materials and components, the introduction of new processes, the opening of new markets or the introduction of new organisational forms (Myers and Marquis, 1969; Gopalakrishnan and Damanpour, 1997; Fagerberg, 2005). Most companies organise the innovation process in projects. The latter are determined plans and routes of development and implementation with the aim of delivering a new product to the market, or new (manufacturing) processes to business (Hobday, 2000). The innovation

process is complex and the different stages (the idea generation, idea selection and formulation, development of the product/process, testing the product/process) develop in a non-linear way.

There are different aspects which complicate the innovation process and put extra requirements on the capabilities of the company to deal with these complexities. A high level of competition in the market puts more pressure on the companies to react with faster and better innovations. It puts pressure(s) on the company to exploit its creative and innovative potential in order to be able to assure high innovation performance. While it is a difficult task to escape the competition pressure (Desarbo *et al*., 2005), companies are better equipped to realise innovations with a high innovation process quality (limitations in speed and costs) and high market potential when they possess the necessary R&D, manufacturing, marketing and organisational skills. These can help them to increase the product and market potential of their innovative products. Products which are new to the market and innovative in the sense of providing technologically smart and unique features can attain a high market potential and increase sales. This means that for the purpose of increasing the potential of an innovation, companies might need to explore completely new and technologically complex innovative possibilities.

While these aspects can increase the market potential, they tend to create more uncertainty in the innovation process (Stockstrom and Herstatt, 2008). This restricts the ability to foresee the outcomes of each step and planning of the innovation process, complicating problem-solving (Atuahene-Gima and Evangelista, 2000) and inhibiting the successful execution and completion of the innovation process. Newness of the innovation project to the firm increases the chance that the existing resources and capabilities of the firm are not adequate for the innovation project (Tatikonda and Montonya-Weiss, 2001; Garcia and Calantone, 2002; Zhou *et al*., 2005; Sirmon *et al*., 2007). Completely new projects put large demand on the capabilities of the firm to deal with unexpected findings and adjustments. The uncertainty created by the novelty and newness may slow down the innovation process or make it more expensive because more time and investment may be needed than initially thought.

With these aspects complicating successful innovation, innovative companies need to be equipped with sufficient and adequate innovation capabilities in order to attain high performing innovation projects. Through improved innovation process quality, planning, preparation and continued assessment of the innovation process, companies can assure that they enable adequate functional (upstream and downstream) innovation capabilities to attain high innovation performance. Communication capabilities can increase the innovation project performance through a higher level of understanding of the possibilities of the integration of cross-functional capabilities, the necessary adaptations in the collaboration and/or capabilities and problems which need to be solved, whereas communication can enhance the innovation performance (see Table 2.2 in Chapter 2, Section 2.4 for an overview of the operationalisations of the concepts from the model depicted in Figure 3.1). In the following section, we will zoom in on innovation capabilities and explain further the importance of these for the high innovation project performance.

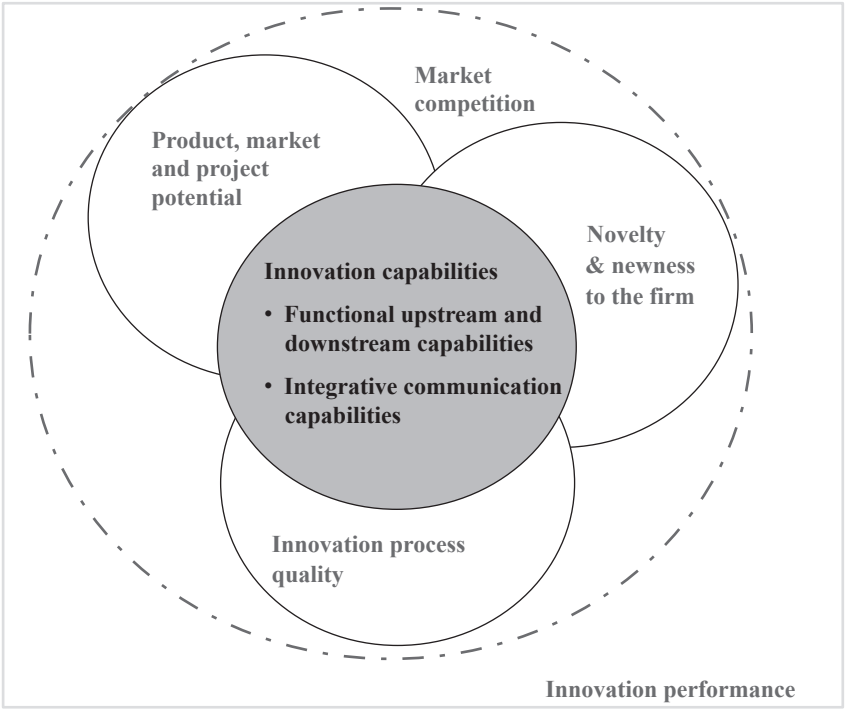

Figure 3.1 *Research framework.*

3.2.2 Innovation capabilities

Having the right capabilities to conduct innovation is one of the most important aspects for the long-term survival of innovative companies. A firm's capability entails the '*firm's ability to perform a productive task which relates either directly or indirectly to a firm's capacity for creating value through effecting the transformation of inputs into outputs*' (Grant, 1996, p. 377). A capability is also defined as the integration of various kinds of special firm assets or resources (Guan and Ma, 2003) which are heterogeneously distributed within the company. When matched with the external environment in an appropriate way, specific firm resources and interior capabilities constitute the basis of competitive advantage of the company (Guan and Ma, 2003).

Innovation capability (Coombs and Metcalfe, 2000) entails the skills and knowledge needed to effectively absorb, master, and improve existing technologies, and to create new ones (Lall, 1992). It entails the ability to quickly introduce new products and to adopt new processes (Guan and Ma, 2003), involving a wide variety of assets and resources (Sen and Egelhoff, 2000). Innovation capability is the ability to mould, manage and integrate the different capabilities and resources of the firm to stimulate innovation successfully (Lawson and Samson, 2001)

i.e. the firm's ability to react by adapting resources to the changing requirements of customers or changing technologies (Wang *et al*., 2008; Goddard *et al*., 2010). Innovation capabilities surface in previous research as determinants of innovation project performance (Globe *et al*., 1973; Davidson, 1976; Hopkins and Bailey, 1976; Lazo, 1965).

With the SAPPHO studies (Rothwell, 1972; Rothwell *et al.,* 1974) as one of the pioneer studies, aspects such as understanding of users' needs, attention to product advantages, market attractiveness (large and growing market, low overall intensity of competition), and internal organisation (in terms of pre-development planning, early cross-functional, customer, and supplier involvement, sufficient resources, and better teamwork) are emphasised for innovation project assessment. Planning is considered important because it includes for a large part orientation of the innovation process to the market, including accurate prediction of market potential (Kim and Wilemon, 2002; Balbontini *et al.,* 1999). This enables the firm to jump into the possibilities of and steer the innovation process towards high market and project potential. Important 'up-front' activities include initial screening, preliminary market and technical assessment, detailed market research or feasibility studies and commercial evaluation of the innovation project (Stockstrom and Herstatt, 2008; Barczak 1995, Calantone *et al.,* 1997, Song and Parry, 1997). Proficiency in technological-related activities (in-house testing, pilot production, production start-up, obtaining necessary technology) is important for the implementation of the project (Stockstrom and Herstatt, 2008). This points to the importance of functional innovation capabilities, such as R&D, manufacturing and marketing capabilities (Guan and Ma, 2003).

Functional innovation capabilities play an important role in the execution of the day-to-day activities necessary for the development of the product (Narasimha, 2001; Croom, 2001; Cepeda and Vera, 2007). These are divided into upstream and downstream capabilities. Upstream capabilities entail the R&D capabilities that are needed to deal with novel technologies and approaches in case of development of new technological assets (Yam *et al*., 2004). It also entails the manufacturing capabilities which enable the firm to transform R&D results into products which meet market needs and design requests and/or technological possibilities as well as the ability to manufacture the innovation at large (Guan and Ma, 2003; Yam *et al*., 2004). Downstream capabilities involve the marketing capabilities which represent the craft of promoting and selling the product on the basis of the understanding of consumers' current and future needs, awareness of a suitable strategy for approaching the customer and sufficient knowledge about the competition (Guan and Ma, 2003). Technical and market-directed feasibility studies assist companies to plan for the necessary functional innovation capabilities enhancing the innovation process speed and quality as well as market potential of the innovation.

Whether a company is equipped to adapt its functional capabilities with the necessary changes is largely determined by the communication capabilities of the team members (Perez-Freije and Enkel, 2007). These communication capabilities are necessary to assure adaptation of

the available resources and skills to deal with the uncertainties in the innovation process. Communication among the team members is at the core of integrative absorption of (tacit) knowledge and different technical competencies (Hirunyawipada *et al*., 2010; Imai *et al*., 1985, Clark and Fujimoto, 1991; Edmondson and Nembhard, 2009). Cross-functional combination of perspectives (Bunderson, 2003; Cummings, 2004) in a highly interactive and iterative fashion and breaking of routines contribute to higher innovation performance (Allen, 1966; Allen *et al*., 1969). Cross-functionality makes the communication capability (Edmondson and Nembhard, 2009) central to the integration and paralleling of all the functional innovation capabilities (Blindenbach-Driessen and Van den Ende, 2006). Communication capability also enables a better definition of goals and plans and leads to clarity about priorities among the team members. Communication enhances the integration of knowledge about engineering, market conditions and customer preferences and increases competence for problem-solving (Lynn *et al*., 2003). Frequent and appropriately structured task communication leads to more comprehensive and varied information flow to the team members (Brown and Eisenhardt, 1995; Lawson and Samson, 2001). Integration of knowledge and increase in the understanding of the requirements of the innovation project takes place when team members with different functionalities and expertise are able to discuss and confront each other in a constructive way (Thompson, 2003; Atuahene-Gima, 1995; Souder *et al*., 1997; Mishra *et al.,* 1995; Parry and Song, 1994). Communication increases the understanding of the potential problems in the project whereupon actions can be taken and plans can be adjusted. As communication is at the heart of the firm's ability to execute the innovation project in an efficient and effective way (to understand the requirements of the uncertain innovation process better and faster), in the present paper, communication capabilities, next to functional capabilities, are considered among the essential dimensions of innovation capabilities.

In contrast to the high value-added products developed in the pharmaceutical sector, highly innovative products in the food industry have a lower prospect of earning back the R&D investments. New product development is an expensive and risky business for F&B companies, as the response time (the time before imitations appear) is rather short due to the competition by food retailers that often imitate under 'own-label' (Senker and Managematin, 2008; Charlebois, 2011). In combination with the relatively limited experience with technological innovation, the consumer-related uncertainty and the increasingly demanding legal requirements with regards to food safety and quality make the innovation process in the F&B sector complex, time-consuming and risky (Sarkar and Costa, 2008). The capabilities of firms to deal with the challenges of innovation, assuring adequate resources and fast adaptation to the conditions in the business environment, are considered to be critical for successful innovation. Therefore, in this paper it is tested whether the capabilities and factors important for innovation performance in technology-based companies apply in the F&B sector. In the following section, the specific conditions in the F&B sector will be discussed first, focusing on the differences between innovation in the F&B and technology-based sectors.

3.3 Comparing innovation in the food and beverages vs. technology-based industries

The F&B sector takes up an important position in the Dutch economy. With a turnover of 51 billion euro and 9 billion euro of value added, the food and beverages industry is one of the pillars of Dutch industry (FNLI, 2010). It is a driver of Dutch exports and the sixth largest F&B industry in the European Union. With such a significant role in the Dutch economy, it is important to study the innovation performance of companies in the F&B sector.

Figure 3.2 shows that the investment in biotechnology in the F&B industry is no longer negligible when compared to the chemical and pharmaceutical industries. As the technological character of the F&B industry is increasing, it is interesting to assess whether the F&B companies require different innovation capabilities to attain high innovation project performance.

The larger role of technology in the F&B sector means that innovation capabilities have become an important element for success and competitive position for the companies in this sector. However, differences such as the much lower levels of investment in research and development in the F&B sector than in other industries point to the possibility that the innovation process in the F&B field may have different preconditions and require different innovation capabilities. For example, Figure 3.3 demonstrates that compared to technology-based industries, F&B industry shows a considerably lower level of R&D intensity (R&D intensity is calculated as the quotient of the expenses on R&D with own employees and the Gross Value Added (GVA)).

Figure 3.4 shows that only 10.1% of the companies in the food and beverages industry are classified as innovators while this percentage is higher in technology-based sectors: 27%

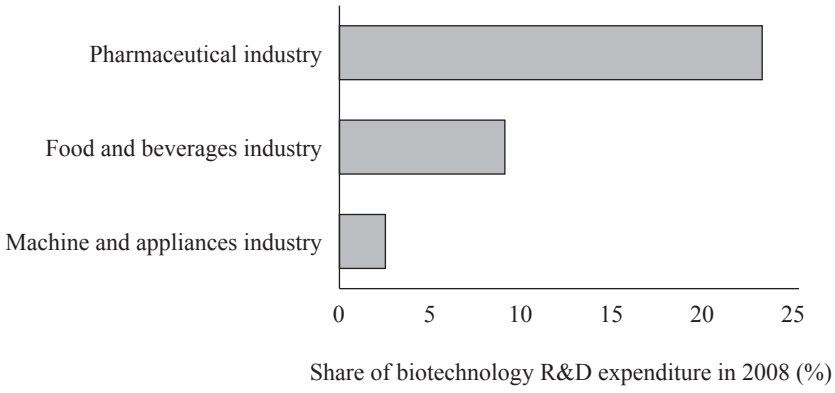

Figure 3.2 *Share in biotechnology R&D expenditure 2008 (CBS, 2010).*

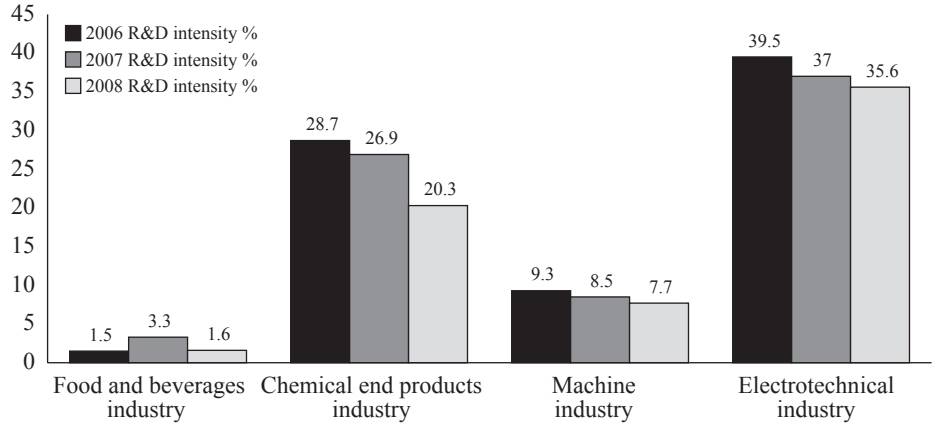

Figure 3.3 *R&D intensity in the F&B and tech-based industries (CBS, 2010).*

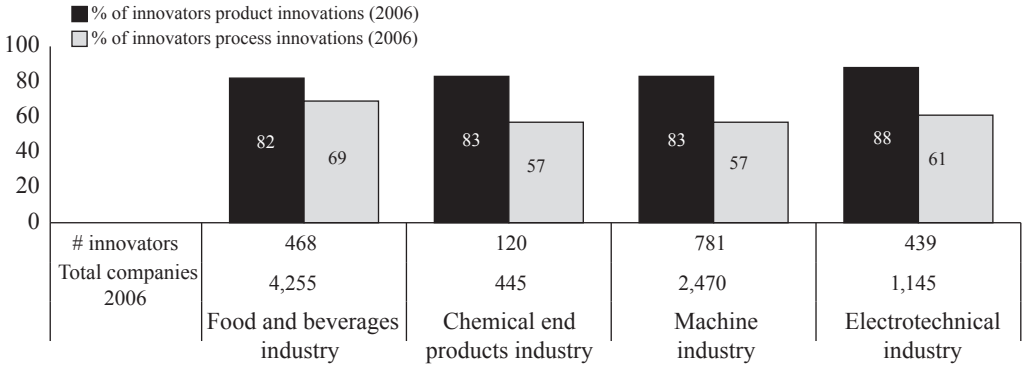

Figure 3.4 *Innovators in product and process innovation in the F&B and technology-based industries (CBS, 2010).*

in the chemical end-products industry, 31.6% in the machine industry and 38.3% in the electro-technical industry. The innovators in the different sectors dedicate a similar amount of attention to product innovation, whereas the innovators in the F&B industry dedicate a slightly higher amount of attention to process innovation (see Figure 3.4). Figure 3.5 shows that the share of turnover from new products is smaller in the F&B industry than the total industry average (CBS Statline, 2010). It also shows that the F&B industry acquires slightly more of its turnover from products which are new to the company than products new to the market. This might hint at more incremental innovation in the F&B industry.

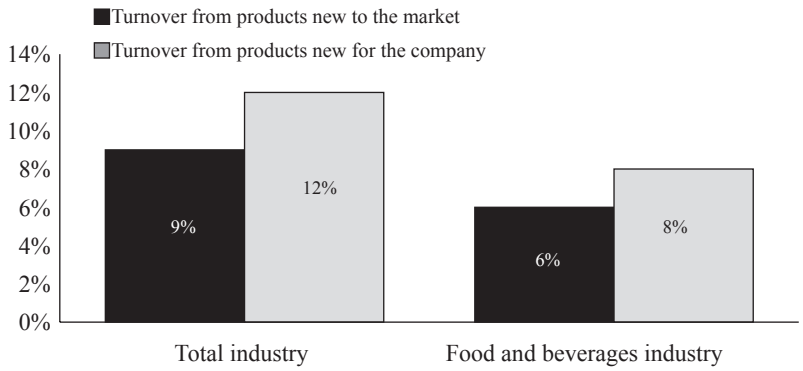

Figure 3.5 *Turnover from product new to the market and new to the company (FLNI, 2010).*

The share of sales from incremental innovations in the food and beverages industries was 10.0% in 2004 (see Figure 3.6), while in the case of the electrical, automobile and transport, and machinery industries, the share of sales from incremental innovation ranged between 16.3% and 20.8% in 2004. The share of sales from radical innovation in the F&B sector was 4.7% in 2004, while in the case of electrical, automobile and transport, and machinery industries this ranged between 7.8% and 11.6% in 2004. These figures confirm that the share of turnover from innovation in general is lower in the F&B industry than the technology-based sectors and indicate that this is the case for both, incremental and radical innovation (the difference between F&B and technology-based sectors is even larger in the case of incremental than in the case of radical innovations). This can be related to the relative difficulty in earning back the investments from product innovations in the F&B sector (FNLI, 2010). This difficulty is related to the dominant position of the retailer in the F&B sector in terms of making an innovation successful, but compared to other industries a lower engagement in co-innovation. In contrast to technology-based sectors, in the F&B industry there is more of a custom of developing products/innovations commissioned by the buyer instead of in cooperation with a

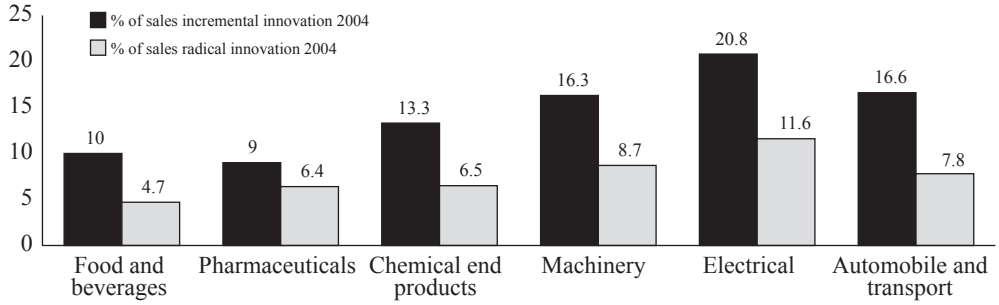

Figure 3.6 *Percentage of sales from incremental and radical innovation (Batterink, 2009).*

buyer. In the technology-based sectors, it is more customary to collaborate and work together towards a solution than in the case of the companies from the food industry. Due to the lack of co-investment in innovation, the advantages from innovation do not always end up with the party that has made the investment in the F&B sector. This is exacerbated by the difficulty of protecting the intellectual property rights in the food industry (ABN Amro, 2008).

Perhaps one of the greatest challenges for successful innovation in the F&B industry is the ability to meet customer demands. Innovative food companies indicate that uncertainty about demand is one of the most important obstacles to innovation (CBS Statline, 2010). As Figure 3.7 shows, the percentage of companies which experience demand uncertainty as obstructive to innovation is higher in the F&B sector than the industry average. The problem is that demands are differentiated per sales-channel. This uncertainty is created by the difficulty of assessing whether the consumers are willing to adopt the new product. The latter tend to behave in a path-dependent way without much willingness to change their eating/food habits. They are rather distrustful about new technologies in the food industry (Bartels *et al*., 2009; Stern *et al*., 2009; Siegrist *et al*., 2009), for reasons such as health hazards or quality losses in innovative foods. Knowledge about the customers/consumers is important for each industry. However, in the food industry this is a particularly important aspect because consumer health and safety and quality criteria need to be accurately matched with the innovation. As co-innovation with the retailers (the chain-actor with most information about the customers and the market) is more limited in the F&B than in other sectors, it is a more specific challenge for the companies from the F&B than the technology-based industries to gather knowledge about consumers and match it to its innovation processes.

This section indicates the differences between the F&B and technology-based industries. The question is whether the previously identified factors for innovation management in the technology-based sectors are also useful to attain successful innovation in the F&B sector.

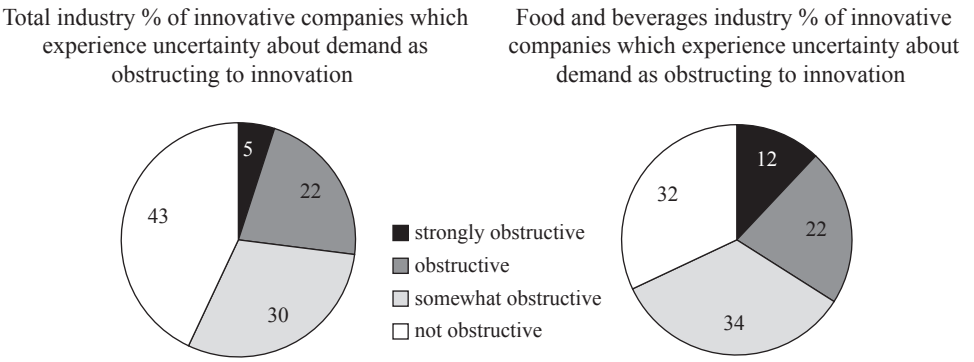

Figure 3.7 *Perception about demand obstructing innovation (FNLI, 2010).*

This will be explored in the results section after the method of data collection and analysis is explained in the following section.

3.4 Data and methods

Data from 38 projects were collected using questionnaires which were completed by 189 project team members (on average 4 to 5 team members per project), including engineers, marketing and sales, and procurement staff. In order to prevent biased answers and acquire tacit information about the adequateness of skills and capabilities, as well as the communication processes and understanding among one another, team members from different departments were asked to complete the questionnaire. Thirteen successful projects (40 respondents) and five innovation projects (18 respondents) that failed in the market from the F&B sector were included in the analysis. In addition, nine successful projects (56 respondents) and eleven failed innovation projects (75 respondents) from technology-based companies were included in the analyses. Data were collected in nine multi-national companies (five F&B processing companies and four technology-based companies). The number of employees per company ranged between 1,300 and 50,000 and 2010 turnover ranged from 0.4 to 8.2 billion euro. Eight of the companies are headquartered in the Netherlands and one in France. The activities of the F&B companies range from crop protection and seed production, potato production, milk processing, vegetables processing to meat production. For example, the crop protection and seed production company introduced a new type of tomato to the market. Through innovation at the component level, they developed the specific shape, substance and the balance of sourness, sweetness and juiciness of the tomato which is most appealing to customers. The potato producing company introduced to the market a new type of fries which were developed in such a way to taste the same, but to contain 33% less fat than regular fries. The technology-based companies included in our study are engaged in the production of high-tech precision products for businesses and provision of high level utility services. An example of one of the projects from the technology-based companies is the development of a new type of bearings. As excellent electric insulators, with a higher speed capability and providing a longer service life, these bearings offer a greater product advantage to the customer.

In each of the participating companies contact was established with the head of the R&D/ innovation department, or the project manager which dealt with innovation in the company. Together with the innovation/R&D manager, a number of successful and failed innovation projects were selected. Per project, a questionnaire was completed with general questions about the company profile, the cooperation and sources of information relevant for the project. The questionnaire builds on the NewProd innovation assessment tool (Cooper, 1979) and combines it with questions about communication processes at the group level as developed by Hollander (2002). The questionnaire contains thirty-six 10-point Likert scale questions about perceptions of the innovation team members about the novelty, project newness, upstream and downstream capabilities, communication capabilities, innovation process quality, product potential, market potential, project potential and market competition

(see Chapter 2.2, Section 2.4 Table 2.2 Measurement model). The respondents were asked to indicate to what extent they completely disagree (1) or completely agree (10) with the statement underlying these factors. Innovation performance is a bivariate variable measured on the basis of a distinction between projects which attained high performance in terms of engineering/technological accomplishment, but also generation of substantial sales for the company after market introduction. Projects that are either stopped before project completion or market introduction, or found to be a failure in the market was considered low performing.

3.4.1 Analysis

For the purpose of analysing the data, logistic regression was used. Factor scores from the measurement model, including the constructs and items from Chapter 2, are used for the logistic regression analysis and the bivariate comparison test performed in the present study. While the dependent variable is on the project level (success or failure of the project) and the independent variables are measured at the team member level, clustered error correction is used to correct for the assumption that each of the data-points is independent. The clustered error takes into account the interclass correlation and inflates the standard errors, leading to more accurate results.

In the analyses, the probability is estimated that a project is a high performing project, taking into account the predictor variables (novelty, project newness to the firm, product, market and project potential, communication capabilities, upstream and downstream capabilities, market competition and innovation process quality). In order to establish whether the likelihood of a high performing project is significantly different in the F&B and technology-based innovation projects, a control variable was added to the models which distinguished between F&B and technology-based innovation projects. Company size, in terms of the number of employees, is also included in the analysis.

The first model tests only the direct effects, while the second model also takes into account the interaction effects between the independent variables and F&B innovation projects. The first model tests the relationships between the success factors and success and failure on the basis of the entire dataset, whereas the second model takes into account the differences in these relations between the F&B and technology-based industries.

3.5 Results

Table 3.1 provides an overview of the Spearman's rho correlation coefficients among the independent variables. This correlation table shows relatively high and significant correlations between upstream and downstream capabilities, between market potential and product potential and between market potential and project potential. High correlations between these constructs are not surprising as constructs such as upstream and downstream capabilities

Table 3.1 *Correlations coefficients between constructs *p<0.05; ** p<0.01.*

	1	2	3	4	5	6	7	8	9
1. Novelty	x								
2. Newness	0.32**	x							
3. Communication capabilities	0.14	-0.02	x						
4. Upstream capabilities	-0.01	-0.30**	0.48**	x					
5. Downstream capabilities	0.08	-0.25**	0.33**	0.50**	x				
6. Innovation process quality	-0.11	-0.16*	0.22**	0.22**	0.18*	x			
7. Product potential	0.26**	0.00	0.48**	0.29**	0.14	0.25**	x		
8. Market potential	0.26**	0.13	0.39**	0.06	-0.05	0.27**	0.56**	x	
9. Market competition	-0.02	0.02	0.12	-0.09	-0.15*	0.02	0.13	0.22**	x
10. Project potential	0.10	0.04	0.24**	0.05	-0.02	0.41**	0.41**	0.58**	0.13

are conceptually closely related. However, the correlations are sufficiently low not to create multicollinearity problems.

The first model presented in Table 3.2 provides an overview of the extent to which each of the independent variables increase the likelihood of high innovation project performance. The first model does not entail the interaction between the independent variables and the sector. In the second model, the interaction effect between the independent variables and the sector is taken into account which means that the differences can be distinguished between the F&B and tech-based innovation projects. More precisely, in case of a technology-based innovation project, the effect of the variable 'newness' is -0.21 on the logit of the outcome variable project success. In case of an F&B innovation project, the effect of 'newness' is -0.21 – 0.59 = -0.80 on logit of the outcome variable project success. The F&B sector dummy variable can be interpreted as the shift of the constant in case of a significant effect of the sector. The significant interaction indicates that the effect of newness is significantly more positive/negative in the case of the F&B than in tech-based innovation projects. In other words, higher project newness to the company lowers the chance of a successful F&B innovation project. This is also reflected in Table 3.3 where newness is lower in high performing, compared to low performing, F&B and technology-based projects. Table 3.3 provides an overview the bivariate significance of the differences of the mean scores between the F&B and technology-based innovation projects. A significant effect is also found with regards to product potential. The likelihood of high innovation performance of the project increases when the perception of product potential increases. Table 3.3 also shows that product potential is higher in high performing projects but there is hardly any difference between F&B and technology-based projects.

The first model in Table 3.2 indicates that the likelihood of innovation performance of projects seems to be affected by the type of innovation project, F&B or tech-based. When

Table 3.2 *Logistic regression of the probability of high innovation performance.*

Independent variables	Model 1		Model 2	
	B	se	B	se
Intercept	-3.89**	1.45	-3.46	3.16
Novelty	0.02	0.09	0.04	0.16
Newness	-0.31***	0.10	-0.21	0.17
Communication capabilities	0.02	0.18	0.01	0.23
Capabilities upstream	-0.12	0.14	-0.32*	0.17
Capabilities downstream	0.14	0.12	0.07	0.18
Innovation process quality	0.07	0.13	0.04	0.24
Product potential	0.30**	0.13	0.21	0.20
Market potential	0.12	0.17	0.29**	0.14
Market competition	-0.05	0.09	-0.09	0.13
Project potential	0.23	0.15	0.27	0.23
Company size (number of employees)	0.01	0.01	0.02	0.03
F&B	1.49**	0.50	0.83	5.69
Novelty * agrifood			-0.15	0.35
Newness * agrifood			-0.59*	0.33
Communication capabilities * agrifood			-0.71†	0.46
Capabilities upstream * agrifood			1.42**	0.51
Capabilities downstream * agrifood			0.05	0.43
IPQ * agrifood			0.45	0.33
Product potential * agrifood			0.51	0.39
Market potential * agrifood			-1.00***	0.27
Market competition * agrifood			0.25	0.32
Project potential * agrifood			0.02	0.35
pseudo R^2	0.215		0.344	
McFadden's Adj R^2:	0.116		0.169	
Log pseudolikelihood	-102.778		-85.905	
X^2 (df)***	56.41 (12)***		142.69 (22)****	
N	189		189	

(Std. Err. adjusted for 38 clusters in project) * p< 0.10; ** p< 0.05; *** p<0.01; † the t-value of 1.54 is just below the critical t-value of 1.65 for the 10% sign. level.

Table 3.3 *Descriptives (mean scores and standard deviations) and bivariate differences.*

Total mean N=189		F&B			Tech-based		
		Innovation performance high N=40	Innovation performance low N=18	Mann-Whitney Sig.	Innovation performance high N=56	Innovation performance low N=75	Mann-Whitney Sig.
4.32 (2.07)	Newness to the company	3.27 (1.95)	6.00 (2.03)	***	4.21 (1.97)	4.56 (1.92)	
4.44 (2.29)	Novelty	5.46 (2.29)	5.58 (2.41)		4.07 (2.19)	3.89 (2.08)	
6.57 (1.91)	Product potential	7.26 (1.80)	5.95 (2.00)	**	7.16 (1.68)	5.91 (1.87)	***
6.48 (1.52)	Market potential	6.57 (1.49)	6.39 (1.42)		7.06 (1.47)	6.01 (1.47)	***
6.30 (1.58)	Project potential	6.30 (1.71)	5.77 (1.64)		7.02 (1.64)	5.88 (1.24)	***
7.56 (1.33)	Communication capabilities	8.08 (1.40)	7.40 (1.17)	**	7.72 (1.35)	7.20 (1.23)	**
6.66 (1.63)	Capabilities upstream	7.42 (1.79)	5.63 (1.17)	***	6.51 (1.67)	6.60 (1.47)	
6.09 (1.72)	Capabilities downstream	7.00 (1.40)	5.22 (1.76)	**	5.91 (1.66)	5.96 (1.73)	
5.30 (2.10)	Market competition	6.06 (1.89)	6.41 (1.76)		5.05 (2.11)	4.82 (2.10)	
6.03 (1.54)	Innovation process quality	6.07 (1.75)	4.74 (1.48)	***	6.46 (1.48)	6.01 (1.31)	*

* p<0.10; ** p<0.05; *** p<0.01

the interaction effects between the independent variables and the sector dummy variable are taken into account (see model 2 in Table 3.2), a significant effect of the interaction[5] between market potential and the F&B sector dummy means that there is a steeper negative relationship between market potential and innovation performance in the F&B, compared to the technology-based companies.

Higher market potential increases the likelihood of higher innovation performance in general (see Model 1, although statistically not significant), but in the case of the F&B companies,

[5] A significant effect indicates a change in the slope of the regression line.

market potential increases less strongly this likelihood to success than in tech-based companies. Indeed, Table 3.3 shows that the difference in scores between high and low performing innovation projects is much smaller in the case of the F&B than the difference in the case of the technology-based innovation projects. This finding is in congruence with the previously mentioned high uncertainty with regards to the demand and consumer preferences in the F&B sector. Obviously, there is a potential for the F&B companies to improve on the aspect of consumer-oriented and market potential of innovation.

The results demonstrate that in addition to market potential, also innovation project newness to the company has a significant effect on the likelihood of project success. The impact of newness on the likelihood of high innovation performance is negative in general, but the likelihood of high innovation performance is even lower when the innovation project is very new for an F&B company than for a technology-based company (see Table 3.2). This is also reflected by the scores in Table 3.3 where the difference between high and low performing projects with regards to project newness to the company is much bigger in the case of the F&B than the technology-based innovation projects.

The results in Table 3.2 also show that higher level of upstream capabilities increases significantly the likelihood to high innovation performance in projects in the F&B companies, compared to innovation projects in tech-based companies. Table 3.3 shows the larger differences in scores on upstream and downstream capabilities between the high and low performing F&B innovation projects than in the case of the technology-based innovation projects. Accordingly, projects in the F&B which are in the possession of sufficient and adequate functional capabilities have a higher chance of high performance. This is in accordance with previous research which concluded that economic considerations and insufficient skills constitute important barriers to innovation in the F&B. The longer-standing experience of technology-based companies with (technological) innovation means that these companies have built up a larger pool of innovation-related competencies over the years. It is therefore not surprising that the upstream capabilities are found to be more important determinants of innovation performance in F&B than in technology-based innovation projects.

3.6 Discussion and conclusions

The aim of this paper is to establish how the performance in innovation projects in the F&B and technology-based industries is affected by a number of previously identified determinants of innovation project success. The results show that newness of the innovation project to the company and market potential have more of a negative impact on innovation project performance in the F&B than the tech-based industry. Functional upstream capabilities are specifically important for increasing the likelihood of innovation project success in F&B, when compared to tech-based innovation projects. On the basis of these findings, it is concluded that there is still room for improvement in the F&B companies in order to assure effective management of the innovation project newness to the company. Collaboration with the

supply chain partners can enlarge the functional capabilities of F&B companies, helping them to deal with innovation newness to their company and tackle the innovation market potential weakness. Also, more focus on consumer-oriented integration of R&D and marketing activities can lead to improvement of innovation market potential in the F&B companies.

3.6.1 External collaboration to enhance functional capabilities and ability to deal with newness

Especially upstream, but also downstream (see Table 3.3) functional capabilities are important for the distinction between successful and failed innovation projects in the F&B companies. Companies which are more skilful in assuring the adequate upstream and downstream capabilities for their innovation project have a higher chance of achieving high innovation performance. Newness or unfamiliarity with the technologies, techniques or processes entailed in the innovation project is among the traps for innovation projects success in the F&B companies. Also previous research identified economic considerations and insufficient innovation competencies as barriers to innovation in the agri-food sector (Batterink *et al*., 2006; Garcia Martinez and Briz, 2000). Capabilities for dealing with newness can be improved through external orientation and internalisation of resources and capabilities (Martino and Polinori, 2011). Examples of these are mergers and acquisitions, joint ventures or exchange of staff for the purpose of acquisition of skills, knowledge and new technologies (Bierly *et al*., 2009).

Internalisation of knowledge and capacity from the external environment is still an area of advancement for the F&B companies. As previous research states, collaborative relationships between companies are incompletely pursued in the food sector, when compared to other industries (Weaver, 2008; Fortuin and Omta, 2008). As Ziggers and Henseler (2009) found, F&B companies can engender sustainable competitive advantage by fostering close working relationships with a limited number of partners, building effective network structures and developing a long-term orientation (Ziggers and Henseler, 2009). Collaboration within the supply chain could be one of the solutions for the problems related to investment and return on investment in innovation. Collaboration enables companies to share in the costs of innovation and enlarge the pool of available resources and capacities, but also to make agreements about the distribution of benefits/profits from innovation investments. With improved access to information, knowledge and resources, the F&B companies are in a better position to build a balanced innovation project portfolio including radical (long-term, large-risk) and incremental (short-term, lower-risk) innovations. The importance of long-term innovations is also noted by policy-makers who have introduced the Technology Strategy Board (TSB). For the life sciences in general and the F&B sector in particular, a number of areas where the long-term (breakthrough) innovations can be expected are functional foods, novel food processes, food safety, authenticity and traceability. These are areas where F&B companies can improve profitability through innovation.

3.6.2 Consumer-oriented innovation increasing market potential

F&B companies which are able to increase the emphasis on user-oriented innovations can increase their innovation market potential. Previous research found that, among other things, a lack of concrete guidelines for the effective implementation of consumer-oriented food development and the lack of intra- and inter-organisational coordination or integration of R&D and marketing know-how (Costa and Jongen, 2006) constitute barriers to innovation in F&B companies. While market knowledge and cross-functional collaboration are two fundamental sources for successful product innovation (De Luca and Atuahene-Gima, 2007), findings from the present study show that market potential, but also integrative communication capabilities (although not significant) increase less strongly the likelihood of successful innovation projects in F&B than in technology-based innovation projects. The previous emphasis on the 'technology-push' innovation in the F&B industry may be one of the reasons for the weakness of F&B companies in assuring high market potential of their innovations.

The relatively recent focus on more user-oriented innovation (Grunert *et al*., 2008) may change this situation. There is an increasing focus on the rising demand for individualised products according to customer preferences, short response time, and dynamic adjustments of company competencies according to new market needs or technological opportunities (Grunert *et al*., 2008). For food processing companies, the potential for the largest gains is related to a focus on collaboration with their buyers, which are in this case represented by retail. As previously mentioned, the difference between the technology-based and the F&B industry, in terms of difficulty in attaining a high return on innovation investment, is the absence of actual co-innovation and joint investment in innovations. This also holds for the information about the consumer preferences for innovation in the foods. Retail and the food processing companies could create a win-win situation by focusing on the high sustainability and food quality and safety requirements of the customers. Integration of the knowledge and resources from the F&B companies and retail could result in exclusive products for the co-innovating supermarket, increasing the return on investment for both parties.

These kinds of changes in management turn the focus of F&B companies to combining different functionalities and knowledge to deal successfully with innovation project newness and the understanding of customer preferences to increase the market potential of innovations.

3.6.3 Further research

The present paper contributes to the existing literature by exploring the way in which previous research about critical success factors for innovation projects fits into the conceptualisation of innovation capabilities which lead to high innovation project performance. With the focus on the F&B sector, it is being established in which way the previous findings and existing knowledge about innovation capabilities differ in this specific sector from the more technology-

based sectors. Further extension of the study to companies in other countries and other sectors can contribute to an additional generalisation of the model. In the present paper, the focus is laid on the exploration of functional and communication capabilities. However, other areas, such as the strategic capabilities to integrate external knowledge in F&B companies, can also be explored in further research. Additional focus can be put on the role of organisational routines in innovation project performance. Internal (meta-) routines of absorptive capacity (Lewin *et al*., 2011) can be added by future research as additional determinants of in-house innovation performance. These internal meta-routines include facilitating variation (e.g. solicitation of scientists and engineers to propose and pursue innovative ideas or rotating council of peers to select exploratory projects) and internal selection regimes to enable the emergence of new ideas and selection of ideas for further development (e.g. autonomy of middle management to support and allocate resources to projects). These different practices and routines to internalise knowledge can be used more by F&B companies to improve on the market potential of their innovation.

3.6.4 Main conclusions and recommendations

- Previous research also concluded that economic considerations and insufficient skills can constitute important barriers to innovation in the F&B. Collaboration with the supply chain partners can enlarge the functional capabilities of F&B companies, helping them to deal with innovation newness to their company and tackle the weakness of innovation market potential.
- More focus on consumer-oriented integration of R&D and marketing activities can lead to improvement of innovation market potential in the F&B companies. As co-innovation with retail is more limited in the F&B than in other sectors, it is a more specific challenge for the companies from the F&B than the technology-based industries to gather knowledge about consumers and match it to its innovation processes.

4. Relationship between networking capabilities, absorptive capacity and innovativeness[6]

4.1 Introduction

As indicated in the introductory chapter, the second part of this thesis focuses on the engagement of actors from the agri-food sector in external knowledge absorption and collaboration to improve innovation performance. In Chapter 4 the aim is to increase understanding about the way in which networking and absorption of external knowledge can contribute to the improvement in innovation performance of pig farmers.

In the last decade the Dutch pork sector has experienced a reduction of the number of farms of about 50%, while the number of pigs per farm has almost doubled (LEI and CBS, 2011). Such efficiency leaps are part of the reason why the Netherlands is able to continue to play an important role in the European pork sector. However, because of increased competition in the sector, the price per kilo pork paid to the farmer is decreasing which leads to a continuous drive among the farmers to further lower their costs and increase efficiency. At the same time, the gains in efficiency were often accompanied by compromises in areas such as the environment and animal welfare. The increased societal pressure to invest more in animal welfare and reduction of the environmental burden, as well as the economic and market situation in Europe and beyond, put pressure on the pig farmer to focus on innovativeness and creativeness. The ability to change and innovate is not only dependent on the financial capacity, but also on the ability to recognise, understand and apply new developments and technologies.

In this regard, collaboration with different actors is important (Klerkx and Leeuwis, 2009), such as knowledge-intensive institutes, universities and technology developers, but also butcheries or supermarkets who can contribute to new product concepts. In order to increase understanding about the way in which farmers can use their network to improve their innovative capacity, the relations between farmers' networking behaviour, capacity to ''absorb'' information and innovativeness need to be studied. The research question addressed in Chapter 4 is:

RQ3: *What is the relationship between the networking behaviour and absorption of external knowledge, and innovation and business performance?*

In the present study, absorptive capacity is defined as '*a set of organizational routines and processes, by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability. These four dimensions have a complementary role in explaining*

[6] This study is based on a paper which is provisionally accepted for publication in the International Food and Agribusiness Management Review.

how absorptive capacity can influence organizational outcomes' (Zahra and George, 2002, p. 186). This definition by Zahra and George (2002) differs from previous studies because it views absorptive capacity as a dynamic capability embedded in firm's routines and processes, and because it suggests that the four capabilities are combinative in nature which build upon each other to create and deploy the knowledge necessary to reconfigure other organisational capabilities (e.g. marketing, distribution, and production). While it is considered to '*follow a multidirectional and fluid path, rather than a patterned trajectory of knowledge acquisition and exploitation*' (Zahra and George, 2002, p. 198), the relations between the dimensions of absorptive capacity are studied in a sequential way, from potential (acquisition and assimilation) to realised (transformation and exploitation) absorptive capacity. In the present paper, the multidirectional, rather than the sequential relations, are examined.

While the definition of absorptive capacity developed into '*a dynamic capability that influences the firm's ability to create and deploy knowledge, the* [four] *organizational capabilities*' (Zahra and George, 2002, p.186) are ignored by the stream of research which regards absorptive capacity from a social network perspective. Absorptive capacity is often addressed from this perspective, because knowledge is among the main resources exchanged in innovation-oriented external relations. Absorptive capacity is often studied in the form of proxies of absorption, such as control variables which could account for differences in absorptive capacities among different actors (Reagans and McEvily, 2003) or firm's total expenditures on in-house R&D (Escribano *et al*., 2009). In this way, the organisational capability aspect is overlooked. The present study addresses this gap by considering networking frequency as an organisational capability of the firm reflecting the intensity and direction of efforts to acquire external knowledge. As Lewin *et al*. (2011) argue, although absorptive capacity is a widely used concept, the organisational routines and processes that constitute absorptive capacity remain a black box (e.g. Lane *et al.,* 2001, Zahra and George 2002, Lewin and Massini, 2003, Todorova and Durisin, 2007, Lane *et al.,* 2006). The studies which look at the relation between network structure and innovativeness retain this black box by using proxies for absorptive capacity. In the present study, this shortcoming is addressed by studying how networking behaviour and the ability to acquire, assimilate, transform and exploit the external information and knowledge is related to the level of innovativeness and profitability.

Section 4.2 of the present chapter provides an overview of the theoretical background of the conceptual framework. It addresses definitions and previous research about innovativeness and absorptive capacity. In the third section, previous research about the relation between networking and absorptive capacity is addressed. The conceptual framework and hypotheses concerning the relationship between networking frequency, absorptive capacity, innovativeness and profitability are introduced. In Section 4.4, the method of data collection, the measurements, as well as the structural equation modelling as the method of analysis are introduced. In Section 4.5, the results are discussed on the basis of the model and the tested hypotheses. Also, differences in specific pig farmers' networking behaviour, comparing farmers with high and low absorptive capacity and high and low level of innovativeness are discussed.

In Section 4.6, the conclusions and discussions are presented, including sector implications based on a reflection on the sector.

4.2 Theoretical background

4.2.1 Innovativeness

Innovativeness reflects a firm's tendency to engage in and support new ideas, novelty, experimentation, and creative processes that may result in new products, services, or technological processes (Lumpkin and Dess, 1996; Rhee *et al*., 2010). Although innovations can vary in their degree of radicalness (Hage, 1980), innovativeness represents a basic willingness to depart from existing technologies or practices and act beyond the current state of the art (Kimberly, 1981). While tendency and willingness to innovate (Pallister *et al*., 1998) are important, the extent of adoption of innovation can be considered as a reflection of innovativeness of a firm (Rogers, 2003; Hurt *et al*., 1977, 2004; Calantone *et al*., 2002).

In the case of pig farming, the pressures from society and politics for increased attention to sustainability issues led to the acceptance that innovations and developments need to take into account a balance among the People, Planet and Profit aspects. In order to emphasise the animal welfare aspect, the concept 'Pigs' is added to this list resulting in the People, Planet, Profit and Pigs concept (Hoste, 2010, 2011). This means that besides attention to workers and population, environmental and economic protection for all the participants in the chain, the welfare of the pig is also given specific attention in innovation (Hoste, 2010, 2011). Many of the People, Planet, Profit and Pigs innovations are not necessarily new to the world, but when applied in combination they are new to the pig farms. For example, solar collectors, wind energy and biomass plants are not new to the world, but when applied in a farm, they constitute indicators of a higher level of innovativeness on the People, Planet, Profit and Pigs (4 Ps) innovation scale at the farm. Accordingly, the adoption of a list of 4 Ps innovations is considered to reflect the level of innovativeness of farmers, in the present study.

4.2.2 Absorptive capacity

For the purpose of raising the level of innovativeness, previous research emphasised the importance of learning (Cohen and Levinthal, 1990) and the role of networks in creating access to knowledge and facilitating the learning process (Tsai, 2001; Oliver, 2001; Lane and Lubatkin, 1998; Ahuja, 2000; Ahuja and Katila, 2004). In their seminal paper, Cohen and Levinthal (1990) point to the importance of the firm's capabilities to assimilate and exploit information in generating innovations (Cohen and Levinthal, 1989). Although the idea that the firm's ability to acquire knowledge from the external environment is not originally from Cohen and Levinthal, they did contribute to the existing literature a set of industrial-organisation (IO) economics-based explanations of a firm's absorptive capacity. They argued that if the costs of acquiring external knowledge are small at the time of learning, it is because

the firm has already invested in the development of the ability to identify, assimilate and exploit knowledge from the environment, which is called the firm's learning or absorptive capacity (Cohen and Levinthal, 1989 p. 569).

Knowledge has a central position in the literature which deals with absorptive capacity. It is posited as one of the most important resources of the firm and especially prior knowledge is important for the ability to accumulate new relevant knowledge and learn from other internal or external resources of knowledge. Increased learning in a particular area enhances the organisation's knowledge base in that area, which further increases its absorptive capacity and thus facilitates more learning in that domain (Autio *et al*., 2000, Barkema and Vermeulen, 1998). It is argued that a balance of knowledge similarity and dissimilarity (usually operationalised as complementary resources or capabilities) has been associated with positive alliance outcomes, such as innovation (Ahuja and Katila, 2001, Dyer and Singh, 1998, Jones *et al*., 2001, Lane and Lubatkin, 1998, Larsson *et al*., 1998, Shenkar and Li, 1999). The argument is that absorptive capacity, in terms of the knowledge base and familiarity with new knowledge, results in assimilation of new knowledge (Lane *et al*., 2006). Besides the importance of the knowledge base and knowledge overlap for absorption of new knowledge, the intensity of effort (Kim and Lee, 2002), embeddedness in knowledge networks (Oliver, 2001), and internal integration (Meeus *et al*., 2001) also facilitate organisational learning.

Zahra and George (2002) made a step in the organisational learning capabilities field by introducing a dynamic capabilities perspective of absorptive capacity in terms of four complementary dimensions. They argue that acquisition and assimilation of new external knowledge enable firms to continuously improve, renew and increase their knowledge stocks. In order to complement these long-term pay-offs, firms should also engage in sufficient transformation and exploitation. It is argued that firms' adoption of innovation and willingness to change depends upon effectively developing internal knowledge, utilizing external knowledge, and exploiting knowledge to generate innovations (Kogut and Zander, 1992; Teece, 1996). Firms' ability to assimilate and exploit external knowledge is related to the firms' use of knowledge in the search for innovation. Cohen and Levinthal (1989, 1990) defined absorptive capacity as a firm's ability to recognise the value of new external knowledge, assimilate it and apply it to commercial ends. Given the greater availability of external knowledge sources in modern economies, a dynamic capability that influences a firm's ability to target, absorb and deploy the external knowledge necessary to feed the internal innovation process becomes a crucial source of competitive advantage (Fosfuri and Tribo, 2008). Todorova and Durisin (2007) also point to the capabilities necessary to recognise the value of external information, to transformative processes, and regimes of appropriability. Lane *et al*. (2006) emphasise the dynamic nature of absorptive capacity by pointing to exploratory, transformative and exploitative learning. According to Lane *et al*. (2006), one of the major shortcomings of the existing absorptive capacity literature is the scant attention that has been given to the processes underlying absorptive capacity. Most empirical studies refer to R&D (e.g. Veugelers, 1997; Rocha, 1999; Stock *et al*., 2001; Tsai, 2001), patents (Mowery *et*

al., 1996), or co-authored papers as proxies for absorptive capacity. These indirect measures capture only partially the aspects of capabilities related to valuing new, external information, its assimilation, and its application to commercial ends. There is a lack of direct observation or measurement of the routines that constitute absorptive capacity (Lewin *et al*., 2011).

In the present study, the view is taken that the capability of the firm to organise the access to knowledge from external sources and ability to understand and learn is important. One of the absorptive capacity organisational capabilities is reflected by acquisition which refers to a firm's capability to identify and acquire externally generated knowledge that is critical to its operations (Zahra and George, 2002). The intensity and speed of a firm's efforts to identify and gather knowledge can determine the quality of a firm's acquisitions (Kim, 1997a,b). The organisation of networking behaviour has an important influence on and relation with this identification process. The second organisational capability of the firm is related to the ability of the firm to understand and learn from the new information and knowledge. Assimilation capacity refers to the firm's routines and processes that allow it to analyse, process, interpret, and understand the information obtained from external sources (Kim, 1997a,b; Szulanski, 1996). The third capability of importance for innovativeness is transformation capacity. This denotes a firm's capability to develop and refine the routines that facilitate the combining of existing knowledge with the newly acquired and assimilated knowledge. This is accomplished by adding or deleting knowledge or simply by interpreting the same knowledge in a different manner. The ability of firms to recognise two apparently incongruous sets of information and combine these into an innovation reflects the transformation capability of a firm. The ability to transform new knowledge is important for reframing the firm's definition of the industry and competitive strategy (e.g. Christensen, Suarez and Utterback, 1998). The fourth capability entails the exploitation capacity. This reflects the routines of the firm to refine, extend, and leverage existing competencies or to create new ones by incorporating acquired and transformed knowledge into its operations. Exploitation reflects a firm's ability to harvest and incorporate knowledge into its operations (Tiemessen *et al*., 1997; Van den Bosch *et al*., 1999). It requires retrieving knowledge that has already been created and internalised for use (Lyles and Schwenk, 1992). The outcomes of systematic exploitation are the persistent creation of new goods, systems, processes, knowledge, or new organisational forms (Spender, 1996).

4.3 Previous research and hypotheses

4.3.1 Networking, absorptive capacity and innovativeness

The relationship between networking behaviour and absorptive capacity is addressed by previous studies within the social network theory. For example, Tsai (2001) explored the relationship between network position, absorptive capacity and business performance. He establishes that the interaction between absorptive capacity and a central network position has a positive effect on business unit innovation and performance. Although they regard absorptive capacity as technological distance and not as organisational capacity, Van Gilsing *et al*. (2008)

also establish that a central network position and small technological distance have a better effect on innovation performance, than a central position and large technological distance.

In the present study, we embark on these previous studies in the social network literature by looking at the networking frequency within a wide network range[7] (Granovetter, 1982; Krackhardt, 1992; Burt, 1996, 2005; Reagans and McEvily, 2003). With the focus on the firm's *organisation* of networking behaviour, networking is considered as an organisational capability that reflects the intensity and direction of external knowledge acquisition (Zahra and George, 2002; Jansen *et al*., 2005). Previous research findings, such as the conclusion that the type and degree of ties has an effect on the ability of the firm to integrate and assimilate external knowledge (Goes and Park, 1997), are used to hypothesise on the expected networking behaviour of pig farmers (see Footnote 7 for explanation about the way in which research applying the social network perspective is used to develop the idea about the way in which networking behaviour should be organised).

Interaction with different types of actors may be important for the accumulation of relevant information and knowledge to realise different types of innovations. Knowledge-intensive institutes, such as universities or innovation centres, may be important because they aim at improving pork production and pork chain organisation in the longer term. Technology developers provide new housing concepts, technology for reducing emissions or improvement of animal welfare. For the absorption of knowledge about the wishes and requirements of society, exchanges with animal welfare and environmental organisations may be useful. Also actors from the chain can make an important contribution to the level of innovativeness of farmers. For example, transport companies can have an effect on the perception about the level of innovativeness of the farmer by means of its advanced, innovative or animal friendly transportation methods (Wognum *et al*., 2007). Frequent interaction with multiple actors from the network may increase the amount of knowledge and information about the way in which improvements can be made, new technological possibilities and the way in which technical improvements can be used to meet demands from society and consumers. Reagans

[7] The studying of the networking frequency within a wide network range is based on the ideas and findings from previous research on social network theory. This 'concept' combines the two elements of acquisition of diversity of knowledge (through a wide network range) and depth of knowledge (through strong ties). It is based on the conclusion from previous research that network cohesion (overlapping ties among mutual third-parties) and network range (relationships that span multiple knowledge pools) need not come at the expense of each other, but approach an optimal network structure, which combines elements of both (Burt, 2000; Reagans and Zuckerman, 2001; Reagans *et al*., 2003). This was preceded by the discussion between the importance of strong and weak ties, and between cohesion and structural holes for the purpose of enhancing firm performance and innovativeness. Frequency of contact, as one of the indicators of strong ties (Granovetter, 1982; Krackhardt. 1992), is an important relational trait which is considered to enable transfer of especially *complex knowledge* and information entailed in innovation (Hansen, 1999; Reagans and McEvily, 2003; Krackhardt, 1992; Uzzi, 1997; Van Gilsing and Nooteboom, 2005; Nooteboom *et al*., 2007). While strong ties involve transfer of more complex and tacit knowledge, connection to a widespread network bridges holes and results in exposure to more diverse knowledge (Burt, 1992, 2005; Rosenkopf and Nerkar, 2001; Reagans and McEvily, 2003).

and McEvily (2003) conclude that an individual surrounded by a diverse network could transfer knowledge across a structural hole, even when the connection is weak.

Apparently transferring knowledge and maintaining a diverse network are related, as experience in one of the two helps to achieve the other. Farmers engaged in more frequent networking with a wider range of knowledge sources have a higher chance of a richer exchange of knowledge and in this way become more skilled in approaching specific actors for acquisition of the knowledge that they need. Frequency of interaction and information exchange increases the amount of information the farmers accumulate which contributes to a greater ability to identify and understand the relevant pieces of knowledge for the farm and its innovations. As the higher level of interaction increases the likelihood of (tacit) knowledge transfer and assimilation (Dhanaraj *et al*., 2004), it is expected that:

H1a: *Networking frequency of pig farmers will be positively related to their acquisition capacity.*

H1b: *Networking frequency of pig farmers will be positively related to their assimilation capacity.*

The acquisition capacity of the farmers can be reflected by more skills in collection of knowledge about developments in the sector through discussions with business partners, and through participation in seminars or conferences. More and frequent interaction enlarges the pool of knowledge they acquire and helps them to increase their insight about the developments, innovations and their implications. This is expected to contribute to an increase in their ability to recognise changes in rules and regulations, shifts in market competition and new possibilities to serve their clients and customers. As a result of the time they allocate and skills they developed to establish contact with actors from the chain and network which can provide them with the relevant knowledge, it is expected that the capacity of these farmers to analyse, process, interpret and understand the external changes and developments is positively affected. Therefore, farmers' acquisition capacity is expected to be positively related to farmers' assimilation capacity.

H2: *Pig farms' acquisition capacity will be positively related to their assimilation capacity.*

Furthermore, farms that are more skilled in the recognition of changes in technical possibilities, and which are always among the first to detect changes in rules and regulations and changes in market competition are considered to have the ability to analyse, process, interpret and understand external knowledge and information (assimilation capacity) more quickly. Farms with higher assimilation capacity are also expected to be more skilful in assessing the relevance of new information and knowledge for their farm. The greater ability to understand new possibilities and opportunities is expected to result in more skill in recognising easily the usefulness of new and external knowledge for innovations in the farm and a greater capacity to translate new information and knowledge into changes, adaptations or innovations.

Accordingly, higher assimilation capacity is expected to be positively related to farmers' transformation capacity. It is hypothesised that:

H3: *Pig farmers' assimilation capacity will be positively related to their transformation capacity.*

It is expected that the capacity to transform and apply knowledge to the own farm is positively related to exploitation capacity. The skilfulness in assessing the relevance and usability of new information for innovation in the own farm, the capacity and skilfulness to translate trends in the market and other external information into adaptations in the farm is expected to result in the ability to take an additional step. Farmers with high transformation capacity are also expected to be more skilful in transposing the information into profitable changes and adaptations in the farm. The farmers who are translating new knowledge into actual adaptations in their own farm usually also have an idea about the way in which the adaptation will contribute to increased profit. Therefore, it is expected that:

H4a: *Pig farmers' transformation capacity will be positively related to exploitation capacity.*

The transformation capacity of farmers in the pork sector consists of the ability to use external knowledge about the changes in the market, and combine it with their internal knowledge to make changes to their feed systems, business models or stable (hardware) arrangements. Also their approach to saving knowledge for later use, their availability of resources and skills to build on existing knowledge and translate it into adaptations to their business, demonstrates the transformation capability of farmers. For example, if the farmer is used to regularly discussing the changes and trends in the market with his advisors or personnel, the farmer is more trained to regard and understand the same knowledge in a different manner, acquire new insights, recognise new opportunities and adapt the image about the farm and its competitors. This ability to transform external knowledge in useful applications indicates that the farmer has a greater insight into the possibilities of new developments and technologies. The greater insight into these possibilities is expected to be positively related to adoption of (People, Planet, Profit and Pigs) innovations. Accordingly, it is expected in the present study that:

H4b: *Pig farmers' transformation capacity will be positively related to innovativeness.*

Farms that need little effort to implement new processes in the farm are expected to have a more systematic ability to exploit the external knowledge by incorporating it into their own operations. Those farms which are more proficient in converting external knowledge into profitable applications in their own farm are expected to increase their profitability. Higher profitability due to the implementation of the new systems, processes and organisational forms is a reflection of a greater capability to exploit the external knowledge. The ability of these farms, not only to introduce an innovative application or adaptation into the own company, but also to assure that the gains of the change are exceeding the costs, leads to the expectation that:

H5a: *Pig farmers' exploitation capacity will be positively related to profitability.*

Innovations in the pork sector which are introduced by the farmers are usually process and organisation-related innovations. These are reflected by a higher level of adoption of technological, managerial and organisational innovations. In the present study, innovativeness is interpreted as the level of investment in new, (technological) possibilities or (hardware) improvements in the stables. Within this concept, pig farming systems are developed to cover the needs of the animal, the environment, the farmer and the citizen-consumer. Innovative farmers who are able to combine these four objectives are expected to be more profitable. A high level of innovativeness is required to assure low costs, a speedy production process and/or low amounts of labour per pig and at the same time assure animal friendly treatment of pigs and processes which reduce the burden on the environment (Li and Calantone, 1998). Reducing costs and increasing value by offering products which result from an animal- and environment-friendly production process is expected to result in greater profitability for the farmer. Accordingly, it is expected that:

H5b: *Pig farmers' innovativeness will be positively related to profitability.*

The hypotheses above are captured in Figure 4.1. This conceptual model will be used to analyse the relations between networking and absorptive capacity and innovativeness and profitability among the pig farmers.

4.4 Data and methods

In 2010 the Netherlands produced around 24.9 million *pigs* per year on about 7,000 farms (PVE, 2011a). About 1.0 million pigs were imported and 11.3 million were exported. In addition, the meat exports were three times the volume of meat imports (PVE, 2011b). Germany, Italy and the United Kingdom are important export countries. The competitive position of the pork sector in the Netherlands is largely based on its increasing efficiency levels (Hoste, 2011). In the last decade the sector has experienced a reduction in the number of farms by about 50%, while the number of pigs per farm almost doubled (LEI and CBS, 2011). At

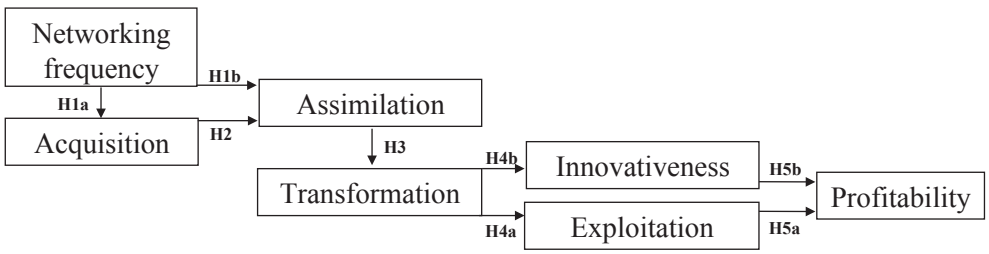

Figure 4.1 *Conceptual model.*

the same time, the efficiency gains were often accompanied by compromises in fields such as the environment and animal welfare. The increasing attention of politics and society to environmental problems and animal welfare concerns resulted in adjustments to legislation, requiring different measures and investments by farmers to reduce food safety related risks, farmers' mineral output and ammonia emissions, and to improve animal welfare. The Dutch government adopted new regulations with regard to animal welfare[8] and the environment[9] which will come into effect by the year 2013 (Baltussen *et al*., 2010). These entail, among other things, that all pregnant sows are to be accommodated in group housing (which is European legislation), fattening pigs are to be given more space, and there is to be a reduction in ammonia emissions and use of antibiotics. These changes put strains on some farmers who will no longer invest in the adaptations required on the basis of the stricter regulations (Baltussen *et al*., 2010). Financial capacity[10] is one of the main reasons for farmers' struggling to fulfil the animal welfare and environment (reduction of ammonia emissions) criteria, but practical problems are also encountered.

For the purpose of increasing the innovative capacity of farmers, information exchange and collaboration with different actors from the chain and network are important (Klerkx and Leeuwis, 2009). Simply studying the interaction with different kinds of actors does not provide sufficient information about farmers' use and assimilation of the acquired external knowledge. Therefore, the absorptive capacity of farmers is also studied directly. The ability to change and innovate is also dependent on the ability to recognise, understand and apply developments, new techniques and technologies within the own company. The fact that the farmers in the pork sector are under increasing pressure to put emphasis on innovation, through learning and integration of innovative ideas and knowledge from the external environment, makes this sector an appropriate field of study to find out how networking behaviour and absorptive capacity relate to innovativeness and profitability.

4.4.1 Sample

For the present study, 1,657 medium to large size farms were selected because they represent the largest group of pig farmers in the Netherlands and provide most insight about the way in which animal welfare and environment-friendly (PPPP) innovations can be applied on a larger scale. The selection criterion for the 1,657 farms was that the farm would count 300 or more sows and/or 1,500 or more fattening pigs. Farms with at least 300 sows cover 73% of the sows in the Netherlands; farms with at least 1,500 fattening pigs cover 62% of the fattening pigs in the Netherlands. About one third of the pig farms have both sows and fattening pigs (CBS, 2011). A large scale survey was administered to these farmers by post. A return envelope was

[8] The Pig Decree.

[9] The Ammoniac Emission Decree for Housing.

[10] In 2008, 56% of the pig farms had a good to reasonable financial position and 13% of the farms run a great risk of having to stop for financial reasons. The remaining 31% of the farms can continue to produce but are in a poor financial position (Baltussen *et al*., 2010).

enclosed to enable the farmer to send back the completed questionnaire. The response rate was 27.9% or 462 responses.

The analysis is performed with 444 farms, after deletion of unusable cases. From these 444 farms, 407 had sows and 402 had fattening pigs. Around two thirds of the farms have 300 or more sows and/or 1,500 or more fattening pigs. This indicates that some farms have sows as well as fattening pigs, but they do meet the selection criterion of at least 300 sows or at least 1,500 fattening pigs. Table 4.1 gives an overview of the sample of farms used in this study. The sample includes farmers with an average age of 47, with a range between 27 to 67 years. In terms of age, the sample seems rather representative as farmers who have confined farms (pigs, cattle, poultry) show a similar picture in age (LEI and CBS, 2011). The largest group of farmers in our sample has a middle vocational training which is also a representative reflection of farmers in the Netherlands (between 50 and 60%) (Van der Meulen *et al*., 2011). In general,

Table 4.1 *Sample overview.*

Farmer	
Age	
Average age	47
Range	27 - 67
Education	# of farmers
Secondary school	50
Middle vocational training	309
Higher vocational training	58
Academic	5
Farm/company	
# of sows	# of farms/companies
<300	138
≥300	269
# of fattening pigs	
<1,500	135
≥1,500	267
Turnover	
<1 million	233
≥1 million	180
Age company	
<20 year	63
≥20 year	379
Successor	
No	266
Yes	163

the average turnover of breeding farms was 336 000 euro and of the fattening pigs farms the average turnover was 546 300 euro in 2010 (LEI and CBS, 2011). Our sample includes medium to large size companies which explains why around 48% of the farms have a turnover of 1 million euro or more. Around 60% of the farmers in our sample has a successor.

4.4.2 Measurements

For the development of the 7-point Likert scale questionnaire, the measurements of absorptive capacity developed by Jansen *et al*. (2005) were used as a starting point. The statements were adapted in such a way as to assure that the pig farmers would recognise their own situation within the statements and complete the questionnaire within 15 minutes. For example, the questions about acquisition developed by Jansen *et al*. (2005) take into account the interactions and exchange of knowledge among the different divisions and units in large firms. However, as even the large pig farms do not have different divisions of employees, only those items which reflect the farmer's own organisational capacity to interact with external actors are taken into account. In the case of acquisition, two[11] of the items from Jansen *et al*. (2005) are adapted and two items are added which focus on the capacity (time and skills) of the farmer to engage in interactions with external actors. The questionnaire was tested by two academic experts on the pork sector in the Netherlands. Next to the questions about absorptive capacity, the questionnaire contained questions about the networking frequency of farmers and questions which provide general information about the farmer and the farm/company (see Table 4.2 for an overview of the operationalisations of the measurements and Appendix 2 for the overview of the questionnaire). In this section the variables used in the model will be described.

Networking frequency

For the measurement of networking frequency a list of potentially relevant actors from the chain and the wider network for pig farmers was included in the questionnaire (see Appendix 2 for the list of actors included). The farms were asked to indicate the frequency of contact with each of these actors. Next to chain actors, (financial) advisors, governmental institutions, branch organisations, knowledge institutes, certifying organisations and animal welfare and environmental organisations are included in the list. As networks create access to new knowledge and facilitate the learning process (Cohen and Levinthal, 1990), it is considered that frequency of contact with relevant actors from a potential network have an effect on the absorptive capacity and level of innovativeness. New knowledge, for example about technology, is often proprietary, tacit, and difficult to value and transfer (Winter, 1987).

[11] Jansen *et al*.'s item: '*We collect industry information through informal means, e.g. lunch with industry friends, talks with trade partners*' (Jansen *et al*. 2005, p.1014). Our item: We collect information about developments in the sector through discussions with business partners from the sector. Jansen *et al*.'s item: '*Our unit periodically organizes special meetings with customers or third parties to acquire new knowledge*' (Jansen *et al*. 2005, p.1014). Our item: Our farm participates at least twice a year in seminars and sector-organized conferences to upgrade our expertise and knowledge.

Frequent interactions allow for a greater openness, and, hence, facilitate transfer of knowledge (Kale *et al*., 2000). The overall networking frequency is considered in the model by calculating the average frequency of contact with a wide range of actors. The higher the overall average score on networking frequency, the higher the level of interaction between the farmer with a wider range of actors. In order to study which specific actors are most important for farms' innovativeness in the field of People, Planet, Profit and Pigs, the largest differences between innovative and less innovative farmers (based on differences in innovation investments) were also discussed.

Absorptive capacity

Different measures of absorptive capacity can be found in the literature. Cohen and Levinthal (1989, 1990) used R&D intensity. Veugelers (1997) and Cassiman and Veugelers (2002) measured it by the presence of a fully staffed R&D department. Others have regarded the human capital level, such as Mowery and Oxley (1995) and Keller (1996) who consider investment in scientific and technical training and the number of scientists and engineers as indicators. Zaheer and Bell (2005) use the residuals from the regression of innovativeness on network structure as the measure of absorptive capacity of the firm.

In the present study, the focus is confined to the definition of absorptive capacity in terms of organisational capacities and routines (Jansen *et al*., 2005) as developed by Jansen *et al*. (2005). *Acquisition* capacity was measured using four items concerning contact with partners for the purpose of collection of information about developments in the sector, attendance at meetings organised by the sector, time spent on and skilfulness in establishing contact with the relevant parties from the network. Six items were used to measure *assimilation* capacity. The statements concerned the skills and capacity to be among the first ones to detect changes in the market, regulations and technical possibilities, as well as time spent and skilfulness in deliberation with advisors to detect changes in the market and the way in which adjustments in the own farm can be made to react to these changes. Five items were used to determine *transformation* capacity. It was asked to what extent information is stored for later use, to what extent the farms are skilful in the assessment of the usability of external information, the time spent and skilfulness in the translation of acquired information to changes and adjustments in the business of their own farm. Three items were used to measure *exploitation* capacity. The farms were asked about their capacity to immediately translate external information to new and improved business applications, whether the use of the acquired information contributes to their profitability, the time spent and skilfulness in the conversion of acquired information into profitability.

Innovativeness

In the context of the current study, innovativeness among pig farmers is demonstrated by engagement in and introduction of new concepts and processes. The level of innovativeness

has been measured on the basis of the level of investment in a list of 24 possible People, Planet, Profit and Pigs (4 Ps) innovations. For an overview, see the questionnaire in Appendix 2. In the model, the average score for all 24 innovations is considered as the measure of innovativeness. All of the 24 innovations are considered to have the potential to contribute eventually to profit.

Profitability

Due to the sensitivity about information concerning the profitability of the farmers, three seven-points Likert scale items were used to measure profitability. The farms were asked to indicate how profitable they are compared to their competitors, whether their turnover and growth is higher or lower than in the case of their competitors. This type of Likert scale has been used often (Powell, 1996) and has proved historically to be highly correlated to accounting measures of performance (Baker and Sinkula, 1999; Balakrishnan, 1996; Dess and Robinson, 1984; Venkatraman and Ramanujam, 1987), such as return on sales or return on assets (Powell, 1996). These are also regarded as reliable means of assessing performance (Pearce *et al*., 1987).

Method of analysis

The questions asked in the present study are directed at the farmers. However, as the farmer is usually the only employee at his farm, the farm can be considered as the unit of analysis in the present study. The data were analysed using structural equation modelling and Lisrel 8.72.

Structural equations modelling was performed to estimate direct and indirect effects. This type of analysis has the advantage of correcting for unreliability of measures. Table 4.2 provides an overview of the mean scores per item and construct, as well as the validity, reliability and internal consistency of the measurement model. The constructs display satisfactory levels of reliability, indicated by composite reliabilities ranging from 0.79 to 0.87 (Kline, 2010). All multi-item constructs met the criterion of convergent validity, with loadings significantly related to its underlying factor in support of convergent validity (Kline, 2010).

4.5 Results

The mean scores in Table 4.2 indicate that in general, the absorptive capacity of the pig farmers turns out to be mainly represented by deliberation with advisors for the purpose of acquisition and understanding of external developments and changes which makes them simultaneously strong in the identification of the relevant sources of information. So, in general, it is these aspects of acquisition and assimilation capacity which are the strongest in terms of absorptive capacity of pig farmers. The capacity to transform and exploit external knowledge is in general a weaker part of absorptive capacity of the farmers. Overall, they have a moderate capacity to be among the first ones to recognise technical, regulatory and market competition changes

Table 4.2 *Overview of mean scores per item and construct, as well as validity, reliability and internal consistency of the measurement model.*

	μ	sd	λ	R^2	α & CR
Networking frequency					
Average frequency of contact with a list of actors	2.8	0.5	0.90	0.80	
Acquisition	4.5	1.3			α = 0.79
We collect information about developments in the sector through discussions with business partners from the sector.	5.0	1.3	0.48	0.23	CR = 0.82
Our farm participated the last year at least twice in meetings organised by the sector.	5.1	1.8	0.68	0.46	
We attribute a lot of time to the establishment of contact with parties which can provide us with knowledge and information about innovations in the sector.	4.3	1.5	0.83	0.69	
We have sufficient skills to establish contact with parties which can provide us with knowledge and information about innovations in the sector.	4.0	1.6	0.88	0.77	
Assimilation	3.7	1.2			α = 0.87
Our farm is always among the first to recognise shifts in technical possibilities.	3.7	1.4	0.87	0.75	CR = 0.90
Our farm is always among the first to recognise regulatory changes.	3.8	1.4	0.81	0.65	
Our farm is always among the first to recognise changes in market competition.	3.8	1.4	0.82	0.67	
Our farm is very skilful in detecting new possibilities to serve new customers.	3.6	1.6	0.83	0.69	
Transformation	4.1	1.2			α = 0.86
We devote a lot of time to discussion with advisors about new trends in the market.	4.4	1.6	0.70	0.50	CR = 0.86
New information about developments in the sector is being stored for future reference.	4.4	1.7	0.54	0.29	
We are very skilful in recognising quickly the usefulness of new, external knowledge.	4.4	1.5	0.73	0.53	
We discuss monthly with external advisors about the way in which changes in the market can be used to improve business at our farm.	4.3	1.7	0.61	0.38	
We devote a lot of time to translation of external information into adaptations to our business.	4.2	1.6	0.78	0.61	
We translate external information directly into new business applications.	3.3	1.4	0.71	0.50	

Table 4.2 *Continued.*

	μ	sd	λ	R^2	α & CR
Exploitation	4.2	1.3			α = 0.87
The use of externally acquired information often contributes to our profitability.	4.1	1.5	0.76	0.58	CR = 0.87
We devote a lot of time to applying of acquired information in order to realise profitability.	4.3	1.5	0.88	0.78	
We have sufficient skills to convert external information into profitability.	4.1	1.5	0.85	0.73	
Innovativeness	2.0	0.7			
The average extent of investment in a list of 24 hardware applications in the stables.			0.95	0.90	
Profitability	4.4	1.0			α = 0.81
How do you estimate your profitability compared to your competitors.	4.6	1.1	0.85	0.72	CR = 0.85
Compared to our most important competitors our turnover is higher.	4.4	1.1	0.79	0.62	
Compared to our most important competitors our growth percentage is higher.	4.2	1.3	0.78	0.60	

μ= mean score (range 1-7); λ = Standardised Structural Coefficient; R^2= Reliability; α = Alpha Cronbach; C.R. = Compound Reliability.

and possibilities to serve new customers, as well as a moderate capacity to translate external information into new business applications and convert these into profit.

Table 4.3 provides the inter-factor correlation matrix for the studied variables. All of the different absorptive capacity dimensions turn out to be rather highly correlated. This is a confirmation of the fact that they represent the different dimensions of absorptive capacity. Correlations with other variables are significant but provide for discriminant validity.

Figure 4.2 provides a visual overview of the structural model and the structural coefficients. The significance of the paths is shown in this diagram. The relative importance of the variables is reflected in the magnitude of the coefficients. The overall fit measures indicate that the model fits the data well ($\chi 2$ (191)= 399.85, $p < 0.001$; GFI = 0.92; AGFI = 0.90; RMSEA = 0.05; RMR = 0.091; NFI = 0.97; NNFI = 0.98; CFI = 0.99). All of the modification indices for the beta pathways between major variables were small, which suggests that adding more paths would not significantly improve the fit.

Table 4.3 *Inter-factor correlation matrix for the studied variables.*

Variable	NF	ACQ	ASS	TRA	EX	INN
Networking frequency (NF)	x					
Acquisition (ACQ)	0.50**	x				
Assimilation (ASS)	0.41**	0.57**	x			
Transformation (TRA)	0.28**	0.61**	0.72**	x		
Exploitation (EX)	0.22**	0.49**	0.58**	0.79**	x	
Innovativeness (INN)	0.30**	0.29**	0.38**	0.34**	0.27**	x
Profit (PRO)	0.17**	0.31**	0.38**	0.49**	0.59**	0.31**

Correlations * $p<0.05$; ** $p<0.01$ (two-tailed); N=444.

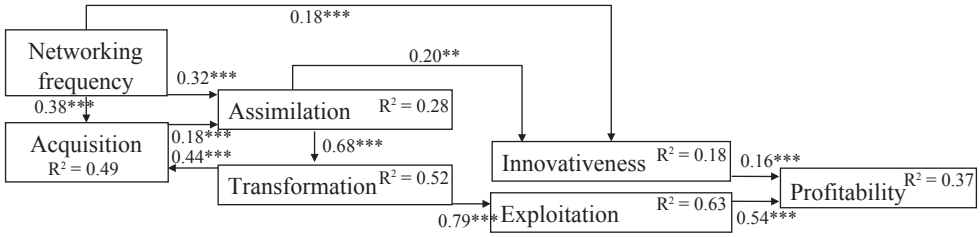

Figure 4.2 *Structural model ** p<0.05; *** p<0.01.*
χ^2 (191) = 399.85; GFI = 0.92; AGFI = 0.90; RMSEA = 0.05; RMR =0.091; NFI = 0.97; NNFI = 0.98; CFI = 0.99

4.5.1. Networking and absorption

The findings from the parameter estimates show that, as expected, networking frequency is positively related to acquisition capability. Pig farmers with higher acquisition capacity have approximately bi-monthly to semi-annually contact with breeding companies, breeding farms, other pig farmers, slaughterhouses, consultancies, the branch organizations LTO[12] and NVV[13], Wageningen University (WUR) and Pigs Innovation Centre Sterksel[14]. An overview of these interactions is presented in Table 4.4. The pig farmers with lower acquisition

[12] *LTO Nederland* (*Land- en Tuinbouw Organisatie*) is the Dutch Federation of Agriculture and Horticulture, an entrepreneurial and employers' organisation, supporting their economic and social position.

[13] Dutch Pig Farmers' Union (NVV) is established to protect the interests of the pig farmers.

[14] Pigs Innovation Center Sterksel is a multi-functional research centre for modern, innovative and sustainable pig farming. The research covers all aspects of pig farming, including nutrition, welfare, health issues, housing and minerals management.

Table 4.4 *Comparison of networking frequency between innovators with high and low acquisition capacity.*

Acquisition	high	low		high	low		high	low
Breeding companies	■	●	Slaughterhouses	■	●	NVV	■-●	●-∞
Breeding farms	♠	■	Consultancies	♠	■	WUR	∞	⌂
Other pig farms	♠	♣	LTO	■	●	Sterksel	■	∞

♣ = monthly; ♠ = bi-monthly; ■ semi-annual; ● = annual; ∞ = less than annual; ⌂ = never or almost never.

capacity have less frequent contact with these organizations, namely about once a year. More frequent contact, through discussions and participation in sector-organized meetings with the mentioned actors, helps the farmers become more skilful in collecting relevant information and knowledge about developments and innovations in the sector.

Frequent network contact is also positively related to assimilation capacity. As Table 4.5 shows, pig farmers with high assimilation capacity have the highest level of contact (approximately bi-monthly) with breeding farms and consultancies (for example related to feed, technical applications and installation, technical wholesale trade services or business advice). Slaughterhouses and health services for pigs (GD) are contacted approximately twice a year; and butcheries, Product Board Livestock and Meat (PVV), the Ministry of Economic Affairs, Agriculture and Innovation (ELI) and Sterksel are consulted approximately once a year. These farmers have contact with WUR less than once a year, whereas farmers with low assimilation capacity never or almost never have contact with the University. It is remarkable that farmers with the highest capacity to recognize shifts in technical possibilities, regulation and market competition changes have only annual or less than annual contact with the research institutes.

Table 4.5 *Comparison of networking frequency between innovators with high and low assimilation capacity.*

Assimilation	high	low		high	low		high	low
Breeding farms	♠	■	GD	■	●	ELI	●	∞
Slaughterhouses	■	●	Consultancy	♠	■	Sterksel	●	∞
Butcheries	●	∞	Product Boards Livestock and Meat (PVV)	●	∞	WUR	∞	⌂

♣ = monthly; ♠ = bi-monthly; ■ semi-annual; ● = annual; ∞ = less than annual; ⌂ = never or almost never.

However, this frequency is still higher for farmers with high assimilation capacity than for those with low assimilation capacity.

In addition to the expected relations, it was found that networking frequency is positively related to innovativeness directly. Innovative farmers, who invest in 4P innovations, have more frequent contact with actors in the supply chain, banks, advisors and accountants as well as the health services agency for animals (Gezondheidsdienst voor Dieren - GD). This contact ranges from bi-monthly to semi-annually in more innovative farms, while it is semi-annually to yearly in case of less innovative farms.

In addition to the higher networking frequency among farmers who invest more in 4P innovations, differences between different types of innovations were observed. As Table 4.6 shows, farmers who invest to a larger extent in pig welfare innovations have semi-annual contact with breeding farms and Sterksel, and less than annual contact with an additional number of actors, such as supermarkets, butchers, a government innovation institution (NL Agency[15]),

Table 4.6 *Comparison of the networking frequency between groups of innovators with high and low innovation investment.*

Investment in:	**Pigs**		**Planet**		**People**	
	high	**low**	**high**	**low**	**high**	**low**
Breeding farms	■	●	∞	⌂	■	●
Slaughterhouses					■	●
Sterksel	■	●	■	●	■	●
Butchers	∞	⌂	■	●	∞	⌂
Supermarkets	∞	⌂	∞	⌂		
Min Infra			∞	⌂		
NL Agency	∞	⌂	∞	⌂	∞	⌂
Knowledge and education inst	∞	⌂			∞	⌂
Animal welfare organisation	∞	⌂				
Wakker Dier					∞	⌂
Milieudefensie			∞	⌂	∞	⌂
SNM			∞	⌂	∞	⌂

■ semi-annual to annual ● = annual to less than annual; ∞ = less than annual; ⌂ = never or almost never.

[15] NL Agency is the contact point for businesses, knowledge institutions and government bodies on issues related to sustainability, innovation, international business and cooperation. It provides information and advice on financing, networking and regulatory matters to entrepreneurs, (knowledge) institutions and government bodies.

knowledge and education institutions and animal welfare organizations. Farmers who invest in planet-profit innovations meet more or less semi-annually with Sterksel and butcheries, and slightly (less than annual instead of never) more frequently with breeding farms, supermarkets, the Ministry of Infrastructure and Environment (Min Infra), NL Agency, Milieudefensie[16] and the Foundation for Nature and Environment (SNM). Pig farmers who invest more in people-profit-oriented innovations have about semi-annual contact with breeding farms, slaughterhouses and Sterksel and less than annual contact with butcheries, NL Agency, environment and animal welfare organizations such as Milieudefensie, SNM and foundation Wakker Dier, and knowledge and education institutions (such as Van Hall Larenstein).

4.5.2. Absorptive capacity

As expected, a positive relation was found between acquisition and assimilation. A higher capacity to establish contact with partners who can provide relevant information about changes and innovations in the sector (acquisition) impacts positively on the capacity to be among the first to recognize technical, regulatory and market-related developments and to evaluate how changes can be applied to one's own farm (assimilation). Pig farmers indicated that they acquire their information about developments in the sector mainly from discussions with business partners and participation in meetings organized by the sector (such as LTO).

Another expectation which was confirmed is that assimilation capacity has a significantly positive effect on transformation capacity. However, most farmers indicated that they have a low to moderate capacity/skilfulness to detect possibilities to serve new customers and only a smaller group indicated a moderate to high capacity to do this.

The capacity to transform knowledge into applications turns out to have a strongly positive effect on the capacity to acquire knowledge. This finding is logical since the transformation capacity of pig farmers is mostly reflected by their skill to quickly recognize the usefulness of new, external knowledge for applications on their own farms (e.g. by deliberation with advisors with regard to feed, technical applications and installation, technical wholesale trade services or business advice). Skilfulness in assessing the usability of new information, as well as regular deliberation with advisors about the way in which changes and trends in the market can be applied to one's own business, can lead to enhanced capacity to establish contact with the relevant sources of information. Table 4.7 indicates that farmers with higher transformation capacity have a higher frequency of contact with breeders and breeding companies, slaughterhouses and butcheries, but also with feed and feed system companies, other pig farmers, supermarkets, banks, consultancies and accountants, ELI, Min Infra, NL

[16] *Milieudefensie* is a movement of people who are committed and engaged, locally, nationally and internationally to contributing to the resolution of environmental problems (it is a foundation and member of Friends of the Earth International).

Table 4.7 *Comparison of networking frequency between innovators with high and low transformation capacity.*

Transformation	high	low		high	low		high	low
Breeders	■	●	Supermarkets	∞	⌂	NVV	●	●-∞
Breeding farms	♣-■	♠-●	Banks	♣-●	■-●	PVV	●	∞
Feed companies	♣	♠	Consultancies	♣-●	■-●	WUR	∞	⌂
Feed system companies	■	●	Accountants	♣-●	■-●	Sterksel	●	∞
Other pig farms	♣	■	Min ELI	●	∞	Knowledge institutions	∞	⌂
Slaughterhouses	■	●	MinInfra	∞	⌂	GD	■	■-●
Butcheries	■	●	NL Agency	●	∞	SNM	∞	⌂

♣ = monthly; ♠ = bi-monthly; ■ semi-annual; ● = annual; ∞ = less than annual; ⌂ = never or almost never.

Agency, NVV, PVV[17], WUR, knowledge institutes (Van Hall Larenstein), Sterksel, GD and SNM.

As expected, transformation capacity also has a strongly positive effect on exploitation capacity. Skilfulness in assessing the usability and translation of new information for the purpose of application to changes in one's own farm contributes positively to the capacity to apply the acquired information to improvements and changes in one's own business in such a way as to realize profitability. The farmers indicated that especially the allocation of time to the application of acquired information reflects their exploitation capacity.

4.5.3. Absorption and innovativeness

The general picture of investment in 4P innovations by pig farmers is as follows. Of the 444 farmers in the study, 41% have invested in fresh noses farrowing pens, 31.2% in daylight, 36.6% in additional space per animal, 16.8% in conditioned air inlet and 15.4% in mist cooling. These are all pig-welfare-oriented innovations. In terms of planet-oriented innovation, 20.7% have invested in animal warmth recovery and 12.9% in solar panels. In terms of people-oriented innovation, 24.4% have invested in individual registration of feed and water intake and 16.1% in a Corn Cob Mix (CCM) feed facility.

While it was expected that transformation capacity would be positively related to innovativeness, we found that assimilation capacity is especially positively related to innovativeness. Transformation capacity is positively related to innovativeness, but only at

[17] Productschap Vee en Vlees (product board for livestock and meat)

the 0.10 significance level. This means that for pig farmers the capacity to recognize changes in technologies, regulations, market competition and consumer demands is most important to increase their level of innovativeness. Early recognition of these changes increases the likelihood that farmers will invest in 4P innovations. The farmers with higher assimilation capacity invested significantly more in fresh noses farrowing pens, daylight, additional living space, conditioned air inlet, individual registration of feed and water intake and mist cooling. In addition, they invested slightly but significantly more in direct separation of urine and manure, solar collectors, micro-filtering of air, spraying robots, mixing space for sows and rubbing boards.

As already mentioned, networking frequency is also directly related to innovativeness. Table 4.8 shows that farmers with the highest networking frequency invested in a larger number of innovations, while farmers with higher assimilation capacity invested specifically in pig welfare innovations. Farmers with high assimilation capacity invested in five pig- welfare- and one people-oriented innovation, while the farmers with high networking frequency invested in six pig-welfare-, two planet- and one people-oriented innovations. This indicates that assimilation capacity affects farmers' innovativeness by directing them more specifically towards animal welfare.

4.5.4 Profitability

The expectation that innovativeness is positively related to profitability is confirmed. However, this relationship is not very strong. One of the explanations for this may be that profitability in the case of 4Ps innovations does increase but that the return on investment takes more time, having a limited positive effect on short-term profitability. Of course, profitability is also a condition for having the financial room to invest in 4-Ps innovations. However, in the present paper the aim is to establish whether higher innovativeness in the field of the 4-Ps innovations has a positive relationship with profitability. The more general exploitation capacity of acquired

Table 4.8 *Investments among farmers with high networking frequency and high assimilation capacity.*

High networking frequency and high assimilation capacity					
fresh noses farrowing pens	♣	□	mist cooling		□
daylight	♣	□	direct separation of urine and manure	♣	
additional space for living	♣	□	solar collectors	♣	
conditioned air inlet	♣	□	animal warmth recovery	♣	
individual registration feed and water intake	♣	□	rubbing boards	♣	

♣ = farmers with high networking frequency; □ = farmers with high assimilation capacity.

information turns out to be much more strongly related to profitability than investment in these innovations. The capacity and skilfulness to exploit new information and knowledge in terms of application to immediate business improvements contributes positively to the profitability of farms. Table 4.9 gives an overview of the confirmed and rejected hypotheses.

4.6 Discussion and conclusions

4.6.1 Absorptive capacity as dynamic capability

The present study follows the definition of absorptive capacity as developed by Zahra and George (2002), where the absorptive capacity is viewed as a dynamic capability embedded in a firm's routines and processes. The present study finds support for the combinative and dynamic nature of absorptive capacity by establishing in addition to the sequential relationship between the potential (acquisition and assimilation) and realised (transformation and exploitation) absorptive capacity, also a link in the opposite direction. The study shows that the capacity to transform knowledge can enhance the capacity to allocate the network actors who can provide the knowledge about innovations in the sector. This is in line with the dynamic view on absorptive capacity, which states that '*it follows a multidirectional and fluid path, rather than a patterned trajectory of knowledge acquisition and exploitation*' (Zahra and George, 2002, p. 198). In the context of farmers, it is established that farmers with higher transformation capacity look specifically at the way in which breeding can contribute to improvements in their farm and the way in which innovations can be translated into an increase in returns through negotiations about prices (with slaughterhouses). At the same time, the differences in the frequency of contact with a large number of other chain parties and stakeholders indicate that farmers with higher transformation capacity are aware of the value of each actor for a particular innovation and about the effective frequency of contact.

Table 4.9 *Overview of not rejected and rejected hypotheses.*

H1a: Networking frequency of pig farmers is positively related to their acquisition capacity.	Not rejected
H1b: Networking frequency of pig farmers is positively related to their assimilation capacity.	Not rejected
H2: Pig farms' acquisition capacity is positively related to their assimilation capacity.	Not rejected
H3: Farms' assimilation capacity will be positively related to farms' transformation capacity.	Not rejected
H4a: Transformation capacity is positively related to exploitation capacity.	Not rejected
H4b: Farms with greater transformation capacity will show a higher level of innovativeness.	Rejected
H5a: Farms with greater exploitation capacity will show a higher level of profitability.	Not rejected
H5b: Farms with a higher level of innovativeness will be more profitable.	Not rejected

4.6.2 Assimilation

The study also leads to the conclusion that assimilation capacity is the most important dimension of absorptive capacity for innovativeness of pig farmers. This indicates that the factor 'knowing' or the understanding of actor *i* of the knowledge and skills of actor *j* (Borgatti and Cross, 2003) is among the most important dimensions of absorption. The organisational aspects entailed in the acquisition, such as identification of the most important knowledge sources, discussion with business partners and participation in sector meetings (acquisition capacity) contribute positively to the ability to recognise relevant changes and possibilities (assimilation). This leads to the conclusion that absorptive capacity reflected by, for example, the number of employees with an engineering academic degree (Caloghirou *et al*., 2004), are important aspects of absorptive capacity because they resemble the central dimension of absorption, which is assimilation. However, the present study adds to this by showing that the organisation of networking, such as identification of most important sources of knowledge and participation in sector meetings, also constitutes an important organisational aspect for assimilation of knowledge by the firm.

In the context of farmers, it is concluded that the capacity and skilfulness to be among the first to recognise changes and developments in technical possibilities, regulations, market, and possibilities to serve (new) customers increases most the chance to invest in People, Planet, Profit and Pig innovations. Capacity for rapid understanding, and more technical, legislative and business-related knowledge, affects farmers' innovativeness by directing them more specifically towards animal welfare innovations. Farmers with higher assimilation capacity have a wider network of less than yearly and more regular contacts which help them to recognise changes in technical possibilities, regulations, market competition and consumer demands. The most important sources of information about new developments in the sector turn out to be other pig farmers and slaughterhouses from the chain, and from the wider network, consultancies, branch organisation (LTO), knowledge and research institutes (WUR and Sterksel). This selection of actors testifies that farmers with higher assimilation capacity are indeed most interested to increase their understanding about technical, regulatory, market and consumer changes.

4.6.3 Exploitation

The current research shows that investments in People, Planet, Profit and Pigs innovations are positively related to profitability. However, the general capacity to exploit external information and knowledge is more important for profitability than investment in the 4Ps innovations. Allocation of time to apply the acquired information and sufficient skill to convert external information into profitability is most important for the profitability of farms. This is supportive of the previous conclusion that in '*firms with a high efficiency factor, realized absorptive capacity approaches the potential absorptive capacity. Given that profits are primarily created through realized absorptive capacity (Grant, 1996), firms that attain or maintain a high efficiency factor*

are positioned to increase their performance' (Zahra and George, 2002, p. 191). Thus, potential and realised absorptive capacity need to be balanced, because potential absorptive capacity is more long-term oriented and realised absorptive capacity focuses on the more short-term goals (Zahra and George, 2002).

4.6.4 Networking as an organisational capability

The model in Figure 4.2 confirms the strong relationship between the use of the network (sources), learning and absorption (Goes and Park, 1997; Powell *et al*., 1996). The findings from the present study support the conclusion from previous social network perspective studies that network cohesion (overlapping ties among mutual third-parties) and network range (relationships that span multiple knowledge pools) need not to come at the expense of each other, but approach an optimal network structure when elements of both are combined (Burt, 2000; Reagans and Zuckerman, 2001; Reagans *et al*., 2003). The current research confirms the importance of stronger ties for the transfer of detailed knowledge (Granovetter, 1982; Hansen, 1999, Reagans and McEvily, 2003; Krackhardt, 1992; Uzzi, 1997) by showing a positive relationship between networking frequency and pig farmers' innovativeness. At the same time it shows that diversity of knowledge (Burt, 1992, 2005; Rosenkopf and Nerkar, 2001) is important, but confined to a specific range of actors. In the case of investment in pig welfare, frequent contact with Innovation Centre Sterksel and breeding farms in specific, but also with supermarkets, butcheries, governmental innovation and knowledge, education institutions and animal welfare organisations is important. In the case of planet-oriented innovations, it is important to maintain frequent contact with the same list of institutions, but including the Ministry of Infrastructure and Environment and environment-oriented organisations such as Milieudefensie and SNM. The latter have a role in issues such as reduction of manure surplus and ammonia emissions. The list of frequent contacts of farmers who invest in people-oriented innovations resembles that of farmers who invest in planet-oriented innovations. The somewhat wider network of farmers who are engaged in planet and people-oriented innovations than of those who engage in pig welfare may be related to the somewhat higher interest of the planet and profit innovators in the efficiency aspect. While pig welfare also contributes to better and healthier pigs, innovations which are aimed at planet (environment) and people (labour) have a somewhat greater emphasis on efficiency and higher returns than the pig welfare innovations. The greater interest in efficiency in general may be the reason why the planet and people innovators explore a larger amount of possibilities in a wider network.

However, the theoretical contribution of this study is specifically related to the *organisation* of networking behaviour as part of the *organisational capabilities* of the firm. When studied from a social network perspective, the structural and relational aspects of ties are related to innovativeness and innovation performance (Granovetter, 1982; Krackhardt, 1992; Hansen, 1999; Reagans and McEvily, 2003; Burt, 1992, 2005). The role of absorptive capacity is often addressed, but mostly in the form of proxies of absorption, such as control variables which could account for differences in absorptive capacities among different actors (Reagans and

McEvily, 2003) or firm's total expenditures on in-house R&D (Escribano *et al*., 2009). While the definition of absorptive capacity developed into '*a dynamic capability that influences the firm's ability to create and deploy the knowledge,* the (four) *organisational capabilities*' (Zahra and George, 2002, p.186) are ignored by this stream of research. The finding in the present study that networking frequency is positively related to acquisition and assimilation capacity leads to the conclusion that networking frequency can be considered as an organisational capability of the firm reflecting the intensity and direction of efforts to acquire external knowledge.

4.6.5 Practical implications and suggestions for further research

The most important practical implication of this study is that pig farmers should organise their knowledge accruing and learning process in such a way as to recognise shifts in the technical possibilities, regulatory and market competition changes and new possibilities to serve customers. A networking frequency of once every two months with breeding farms and consultancies (feed, technical application and installation, business advice), once every six months with slaughterhouses and Health services for pigs, and around once yearly contact with butcheries, Product Boards Livestock and Meat (PVV), Ministry for Environment, Agriculture and Innovation (ELI) and Pigs Innovation Center Sterksel can help the farmers to organise themselves for a higher level of assimilation capacity. Recognition of these technical, regulatory, market and consumer changes can also be stimulated through organisational routines such as regular meetings with business partners, participation in meetings organised by the sector, time spent on and building of skills to establish contact with actors which can provide the relevant knowledge about innovations in the sector.

The capacity to exploit external knowledge contributes most to profitability. In order to enhance the exploitation capacity, the capacity to transform knowledge is important. Transformation capacity entails discussion with advisors about new trends in the market, storage of knowledge for future use, discussion with external advisors about the way in which changes in the market can be used to improve business and building of skills to recognise quickly the usefulness of external knowledge. Transformation capacity stimulates the farmers to maintain contact with a wide network of actors with different frequencies of contact. Consultancies, accountants, banks and feed companies seem to be the partners with whom almost monthly contact is maintained.

Learning, through assimilation and networking, is important for enhancing the innovativeness and profitability of pig farmers. However, there are additional aspects which affect the level of innovativeness of firms, such as entrepreneurial and market orientation (Hult *et al*., 2004). Entrepreneurial antecedents of pig farmers' innovativeness could be represented by their level of risk adversity. The question of how much risk the farmer is willing to take, which type of innovation he is willing to engage in and how long he would like to continue his business could affect his level of innovativeness. These issues need further investigation.

The level of innovativeness of farmers is also dependent on the type of innovation and the chain-wide organisational requirements (Wiskerke and Roep, 2007; Broring, 2008). Given the

surplus of pig meat in Europe and strong competition in the entire supply chain, cooperation is needed to realise innovation at the chain level. The question is what kind of role the pig farmers need to play in each of the different types of innovations and which (chain) actor should take the lead. A good example is the *Beter Leven* concept, developed by the Animal protection society (*Dierenbescherming*), in cooperation with retailer Albert Heijn and meat company Vion. Animals are produced under higher welfare standards and sold at a slightly higher price. This kind of marketing concepts based on sustainability items is developed further by other retailers and companies. This innovation is successful, but without the engagement of the meat processing company and the supermarket, the farmer could not have realised such an innovation. The supermarkets play a major role in the establishment of the meat price and are important in organisational terms for the realisation of innovation in this area. Interesting for future research is thus the mapping of the role of different chain actors in case of different types of innovations and the specific knowledge (types) exchanges required to enable these different types of innovation. Specific knowledge and collaboration among specific actors for the purpose of solving the welfare problem is different from knowledge and collaboration with actors in the development of new market concepts since innovations take place at the farm, instead of just at the meat processing level.

In addition to the learning and entrepreneurial orientation, as well as the organisational requirements attached to the type of innovation in which a farmer engages, the financial capacity and the general economic situation also need to be taken into account as determinants of innovativeness. The extent to which farmers are successful in assuring financial means for innovation from their network is difficult to establish, but 48% of the farmers do indicate making use of their network intensively for the purpose[18] of acquiring funding or subsidies. When investments in (hardware) stable changes are concerned, it is the poor economic situation which provides less room for investment. For this reason, the farmer needs assurance that added value concepts will last long enough to pay back the additional investments.

The current model may hold for pig farmers in North-West Europe, but farmers in the South and East Europe find themselves at a different level of development in terms of entrepreneurship, professionalisation and efficiency. The relationships between networking behaviour, absorptive capacity and innovativeness are probably very different as they have other routines and perceptions about the sharing of information (study clubs where farmers learn from each other take place in the Netherlands but much less in countries like Poland or Spain)[19]. Further research is needed to find out how networking, learning and innovativeness are related in these different contexts.

[18] Furthermore, 68% use the network intensively for information about veterinary issues, 55% to gather information about rules and regulations, 38% for (information about) animal welfare, 35% for collaboration purposes and 29% for marketing ends.

[19] In addition, production in these and many other countries often takes places in vertical integrations, where innovations are organized differently.

5. Governance mechanisms interplay in co-innovation partnerships[20]

5.1 Introduction

As explained in the introduction, networking and knowledge acquisition for the purpose of innovation in the company is one of the possibilities for deploying the external integrative capabilities of the firm. Another possibility for innovation and knowledge acquisition through external orientation is engagement in co-innovation partnerships. While inter-firm/organisational collaboration has advantages for innovation, it comes with organisational challenges which create the need for governance mechanisms to manage these challenges. In order to explore how the changing conditions and challenges during co-innovation processes can be managed, the study in Chapter 5 focuses on the interplay between structural and relational governance. The research question which is explored in this chapter is:

RQ4: *How can the interplay between structural and relational governance mechanisms tackle the organisational challenges entailed in innovation uncertainty and network heterogeneity in co-innovation partnerships?*

5.1.1 Innovation and uncertainty

Innovation is a process of creative destruction, where the quest for profits pushes a company to innovate constantly, by breaking old rules to establish new ones (Schumpeter, 1934). It is a '*process of interrelated sub-processes, such as conception of a new idea, invention of a new device, and development of a new market*' (Myers and Marquis, 1969). All innovations are typified by uncertainty. However, there is a difference in the level of uncertainty between innovations with differences in scope of the objectives. Uncertainty is determined by the degree of (in)ability to determine '*what to pursue, how to pursue and whether the pursuit is likely to be profitable*' (Sapienza and Gupta, 1994, pp. 1622-1623). One of the most important dimensions of uncertainty, in settings of innovation, concerns market uncertainty or demand uncertainty (Burgers *et al*., 1993). While firms are able to react to demand uncertainty, they are not able to eliminate it, because customer preferences are unstable or changing continuously (Beckman *et al*., 2004). While technological, procedural and organisational changes and innovation can be undertaken to create sustainability and profitability gains for the agri-entrepreneurs, consumer and societal demands and requirements may still generate uncertainty about the potential of the innovation in the market.

Another dimension of uncertainty, relevant to innovation, is task uncertainty (Jones *et al*., 1997). Task uncertainty '*is the degree to which work to be performed is difficult to understand*

[20] This study is based on a forthcoming book chapter in T.K. Das. Inter-partner Dynamics in Strategic Alliances (in the book series 'Research in Strategic Alliances').

and complex' (Blili *et al*., 1998, p. 139). In other words, task uncertainty is the difference between the information required to perform a task and the information already possessed (Sapienza and Gupta, 1994). Uncertainty about the activities which need to be undertaken to reach the innovation goals is inherent to uncertainty in innovation. Uncertainty diminishes the extent to which ex-ante planning can take place and often presses partners towards ex post re-negotiation of contracts, leaving room for conflict (Galbraith, 1973; Tushman and Nadler, 1978). This type of uncertainty can cause delay in the innovation process, lack of progress towards successful or rewarding outcome(s), misunderstandings and/or conflict.

5.1.2 Co-innovation and network heterogeneity

Many companies, and also increasingly companies from the agri-food sector, are engaging in collaboration with other firms and organisations (chain actors and other stakeholders) to realise innovation goals which they could not have realised without the supplement of resources, skills and capabilities of a network of actors (Hagedoorn, Roijakkers and Kranenburg, 2006). In the agri-food sector, these collaborations take often place in the form of co-innovation partnerships (Dyer and Singh, 1998; Koza and Lewin, 1998). Such partnerships can take different forms, but in the Netherlands they are often public-private partnerships where (non) governmental institutions and organisations collaborate with private sector companies, and together fund and operate the partnership. Collaboration between different disciplines and actors with different skills allows for multidisciplinary, problem-oriented solutions. The access to knowledge heterogeneity (Rodan and Galunic, 2004) improves both the creative potential as well as the ability to implement ideas and to execute complex tasks, in general.

While heterogeneity offers advantages for innovation and creativity, it also creates challenges for the collaboration because partners have, next to the common, also individual interests, views, working methods and knowledge. These differences may result in conflict, opportunistic behaviour or immobility of knowledge and information (Omta and Van Rossum, 1999; Dyer and Singh, 1998). Differences exist because partners with heterogeneous backgrounds and from different disciplines circulate in different flows of information (Burt, 2001) and have a lower level of similarity in their attributes, capabilities and expectations (Gulati, 1995). They also have lower levels of shared understanding of professional conduct and technical and managerial standards (Sako, 2006). In the agri-food sector sustainability-oriented innovation, disparate goals, demands and opinions of the various stakeholders can lead to a different interpretation of the same situation (Hall and Vredenburg, 2003). For instance, the long distance between the consumer and the producer leads to differences in knowledge about the production process in the agri-food sector. This may lead to a situation where the consumer is unaware of its own contribution to the unsustainable practices which he opposes. The limited and complex transfer of knowledge from the scientific to the practical field also constitutes a problem, as scientific and practice-oriented actors do not always understand each other to a sufficient extent (Transforum, 2010).

5.1.3 Governance of innovation uncertainty and network heterogeneity

The question is which governance mechanisms can be used to tackle these organisational challenges in co-innovation partnerships. Structural governance, which is based on the norm of efficient organisation, is considered incongruent with innovation, where the norm of exploration and flexibility should prevail. Theoretical attention was directed at relational governance, which offers more flexibility due to the entailing social norms and pressures as modes of organisational control (e.g. Child and McGrath, 2001). This resulted in a lack of attention to the matching of organisational challenges of the knowledge exchange processes with governance mechanisms to arrive at the most effective and efficient outcomes (Foss, 2007). The present study is a first step towards closing this gap in research by considering how the combination and interplay of structural and relational governance can be employed to mitigate the organisational challenges of innovation uncertainty and network heterogeneity to arrive at the most effective and efficient outcomes (Grandori, 1997; Osterloh and Frey, 2000).

While network heterogeneity would plead for more structural governance through formalisation and control, innovation uncertainty requires loose organisation and governance by trust. As both of the conditions are present in innovation partnerships, both structural and relational governance mechanisms are studied in four configurations of high and low innovation uncertainty and network heterogeneity (see Figure 5.1). All co-innovation partnerships entail uncertainty and heterogeneity, but a distinction can be made between lower and higher levels of uncertainty and heterogeneity, on the basis of the novelty of the innovation and the size of the network. The aim is to explore the concerted effect of these two traits on the balance and interplay between structural and relational governance mechanisms in co-innovation where conditions develop over time due to the changes in the innovation and collaboration process. The present study contributes to the existing literature by exploring

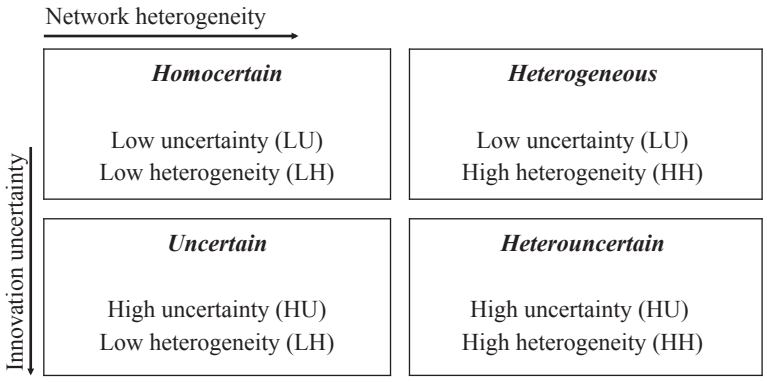

Figure 5.1 *Classification of co-innovation partnerships on the basis of innovation uncertainty and heterogeneity of the network of partners.*

what structural governance exactly entails in the context of innovation and demonstrating that it can offer advantages in tackling organisational challenges in innovation partnerships.

In the following section, the structural and relational governance perspectives are introduced. In the third Section, it is explained how the explorative case study method is used to analyse a collection of co-innovation partnerships which aim at sustainability-oriented innovation in the agro-food sector in the Netherlands. In the fourth Section, the governance mechanisms in 18 co-innovation partnerships are discussed. Four of these co-innovation partnerships are discussed in more depth in order to be able to analyse the way in which the interplay/dynamic among the structural and relational governance mechanisms develops during the collaboration. In the fifth section, conclusions are drawn and discussed in the light of previous research and the existing literature.

5.2 Theoretical background

In the present study, two main perspectives on governance are looked at: the structural and the relational perspective (Faems *et al*., 2008). The main difference between the structural and the relational perspective lies in the basic assumption upon which the two streams of theories are based. The structural perspective is grounded in transaction cost (Williamson, 1985) and contract theory (Hagendoorn and Hesen, 2007), with the arguments and propositions being based on the assumption of self-interested behaviour of the human being. The relational view is based on social exchange theory and the assumption of a 'social' human being, who is able to trust and who can be trusted (Granovetter, 1985; Larson, 1992; Zaheer and Venkatraman, 1995; Gulati, 1995; Uzzi, 1997; Dyer and Singh, 1998).

The structural perspective posits that calculated rational behaviour, which may entail opportunistic or self-interested behaviour, governs exchanges (see Table 5.1). In order to safeguard against opportunistic behaviour, design of detailed contracts and agreements is considered as the remedy (Williamson, 1985; Poppo and Zenger, 2002). Structural governance mechanisms consist of rules, such as ownership rights, that can be observed in, for example, written documents that are determined and implemented by formal authorities (Zenger, Lazzarini and Poppo, 2002). It includes explicit incentives (which reflect the rational commitment), contractual terms and defined boundaries (Zenger, Lazzarini and Poppo, 2002). Agreements contribute to structure and alignment of incentives of partners. Through agreements on confidentiality of information exchange, a safeguard is created which decreases the fear to share information freely, increasing knowledge mobility (Dhanaraj and Parkhe, 2006). Gulati (2007) categorises structural governance into (1) incentive systems (2) monitoring behaviour (3) dispute resolution procedures (4) knowledge protection (5) standard operating procedures that allow quick decisions and (6) command structure and authority systems. In Table 5.1 structural governance is summarised to contractual formalisation as governance mechanism, and rational commitment as the main incentive

Table 5.1 *Governance mechanisms structural and relational perspectives.*

	Structural	Relational
Mechanism	contractual formalisation	trust
Incentive	rational commitment	attitudinal commitment
	calculated and self-interested motive	value of relationship as an asset which yields high returns

entailed in structural governance. Gulati's six-fold categorisation of structural governance is used for the operationalisation of structural governance (see Appendix 3, Table A3.1).

The extensive literature on the relationship between trust and control (Reuer and Arino, 2007; Reuer *et al*., 2006; Klein-Woolthuis *et al*., 2005; Anderson and Dekker, 2005) posits a critical point of view towards contracts and planning, when it comes to cooperation in the setting of innovation. This critical view is due to the limitations of anticipation and planning for contingencies in highly uncertain conditions (Coase, 1988; Simon, 1957). In addition to the limitations which are inherent to the uncertainty entailed in innovation, structural governance mechanisms, such as contracts, are also considered rigid (Håkanson, 1993; Hart, 1989; MacNeil, 1980), limiting the creativeness and liberty to explore (Cheng and Van de Ven, 1996; Holmstrom, 1989). Accordingly, in conditions where innovation and uncertainty paint the picture of collaboration, relational governance mechanisms became the focus of attention.

The relational perspective posits that socially defined, norm-driven definitions of proper behaviours can substitute formalised definitions of these norms (Zenger *et al*., 2002; Dekker, 2004; Grandori, 2006), whereby frequent and high level of information exchange (Caniëls and Gelderman, 2010), including observation and correction of each other's behaviour (Lampel, 2004), play an important role. From the point of view of relational governance, informal norms and rules indicate how decision, control, residual rewards and ownership rights are distributed among the group members. Trust is the social mechanism which governs behaviour from the relational perspective. Trust is based on the expectation that the partner will not take advantage of the actor or intentionally harm his/her interests (Bhattacharya *et al*., 1998; Jones and George, 1998; Hagen and Choe, 1998; Das and Teng, 1998) because of the value attached to the relationship (Bromiley and Cummings, 1992; Mayer *et al*., 1995). Also, it involves reliability of the partner in terms of his/her adherence to a set of commonly accepted principles. Trust develops in conditions of cognitive closeness (McEvily *et al*., 2003) and acquaintance with the reliability (compliance trust) and competencies (competence trust) of a partner. This is the case when there is a frequent and high level of information exchange (Gulati, 1995; Caniëls and Gelderman, 2010). Attitudinal commitment or the value of the relationship as an asset which yields high returns (Johanson and Mattsson, 1987; Jarillo, 1988; Zajac and Olsen, 1993; Madhok, 1995) is the incentive for partners to refrain from

opportunistic behaviour due to the fear of damaging the relationship. Relational governance is summarised in Table 5.1 indicating trust as the main governance mechanism with attitudinal commitment as the main incentive for action. The governance mechanisms and incentives set out in Table 5.1 will be empirically explored, with a conclusion on their definitive compilation at the end of this chapter.

5.2.1 Governance mechanisms interplay – developments in the innovation and collaboration process

Especially in conditions of co-innovation, different forces and motion affect a potential equilibrium and interplay between structural and relational governance mechanisms (Zheng *et al*., 2008). Different stages of the innovation process, including the conception (idea generation, evaluation and project planning), implementation (development/construction, prototype development, pilot application, testing) and marketing (production, market launch and penetration) stage, are marked by different kinds of uncertainty. As described in the beginning of this paper, the more task and demand uncertainty, the more organisational challenges in terms of planning or contract formulation and rational commitment. Network heterogeneity has implications for the governance mechanisms interplay as the development of the relationships among the partners may have an effect on the extent of the relational governance mechanisms present. In the absence of previous collaboration among partners (with different disciplines), the extent of compliance and competence trust, as well as attitudinal commitment, may be lower than among actors where previous cooperation has taken place. Due to these temporal developments, the interplay between structural and relational governance mechanisms are of importance for the outcome and performance of the innovation partnership. For example, in heterogeneous conditions, where limited previous collaboration took place, structural governance mechanisms have the potential to bring structure to the conditions of different interests and backgrounds among the actors in the partnership. Therefore, instead of dismissing the structural governance in conditions of innovation, the potential of the interplay between structural and relational governance mechanisms in innovation partnerships are explored in the present paper.

5.3 Data and methods

5.3.1 Cases selection

Sustainability-oriented co-innovation partnerships in the agri-food sector are a suitable domain of study for exploring the interplay between structural and relational governance mechanisms, because this type of collaboration is a relatively recent phenomenon in the agri-food industry. This means that these newly established networks bring actors together who have a limited track-record of collaboration with each other, indicating that heterogeneity of interests, views and knowledge are present in these partnerships. Stimulation of sustainability-oriented innovation in the agri-food sector was initiated in the year 2004 by the Dutch government

by means of a development and innovation program, called Transforum. Projects from this program are selected for the present study, because their long-term-oriented innovation goals, which are relatively new for the sector, indicated presence of innovation uncertainty. This is an important condition for a study which aims to explore governance mechanisms in innovation conditions. The goal of Transforum was also to bring different actors together in the form of multidisciplinary public-private partnerships (PPPs), which include chain partners, government, societal organisations, research institutes and end-users. This indicated that network heterogeneity was also present to a large extent. The heterogeneity of actors was also considered indicative of the presence of differences of relational governance mechanism, trust and attitudinal commitment. Moreover, public-private partnerships entail agreements among the different parties about the aims, budgets and organisation of the collaboration which means that structural governance mechanisms are present and can be studied. On the basis of these criteria concerning innovation uncertainty, network heterogeneity and governance, 18 co-innovation partnerships were selected to study the (application of) structural governance and the interplay between structural and relational governance mechanisms during the process of collaboration and innovation.

5.3.2 Data collection

With the intention of acquiring information about the process of collaboration over time, only partnerships which existed for three to four years already were selected. Interviews were conducted with managers of the 18 partnerships, in the period from June to August 2009. The in-depth interviews, comprising 32 open questions, were complemented with 33 seven-point Likert scale statements (see Appendix 3 Tables A3.1 and A3.2 for an overview of the measures used in this study) in order to enable a comparative analysis of the differences among the 18 partnerships. The manager was approached for the interviews, because of his general overview of developments in the co-innovation process and his involvement in all the tracks and activities of the innovation. The two-hour interviews were recorded and transcribed. The qualitative data from the interviews were coded using indicators set out in Table A3.1 in Appendix 3. In order to improve data validity, the information collected through interviews was triangulated by means of investigation of initial agreements, meeting notes and interim progress description documents. While the amount of documented information differed per partnership, on average there were around 50 documented pages available per partnership. The initial agreements were investigated, as well as the agreements made after one year of collaboration. In advance of each interview, a number of milestones were identified from the evaluation reports and during the interviews the respondents were asked to elaborate on these. This means that data were collected on the basis of respondent-driven critical incident technique (Flanagan, 1954), which entices the respondents to reflect on the entire process and not to leave out any positive or negative developments, which occurred during the process of the innovation partnership.

5.3.3 Types of partnerships

Predominantly small to medium-sized companies were involved in the partnerships. Five partnership networks included one to two larger companies and the two largest partnership networks included around seven larger companies. In each of the partnership networks two to three knowledge or research institutes are also participating.

With an average budget of one million euro for four years, the goals of the innovation partnerships ranged from the development of animal-friendly poultry systems to agro-parks where sustainable (industrial ecology, high animal-welfare, energy-efficiency and low environmental burden) agriculture is integrated in urban development. Three of the largest partnerships were directed to new forms of regional and knowledge management, branding and communication which allow new businesses to emerge. This enabled entrepreneurs from different sectors to find each other and engage in more effective cooperation between entrepreneurs and governmental bodies. Examples of innovative outputs from these networks are new courses developed by a University of Applied Sciences, a website of the region, regional TV broadcasts and the cradle-to-cradle development of a business park. In seven partnerships, innovations were undertaken which led to a reduction in energy use, waste production and pollution, either through interconnected and exchange of energy and waste streams, or through a sector-wide, concerted effort. Eight partnerships focused on the introduction of new, sustainability-oriented concepts in the market. For example, shortening of the chain led to the opening of a new concept store where locally (sustainably-) produced fruit and vegetables are sold; a new poultry-holding system was used to improve animal welfare and introduce a new egg concept in the market; for agricultural use of the saline seepage in the Dutch coastal provinces, salt-tolerant crops were identified which can be grown in brackish water and used in the same way as fresh-water crops.

5.3.4 Measures

Innovation uncertainty. The differences in aims enabled differentiation of the extent of innovation uncertainty, in terms of task and demand uncertainty. Partnerships with innovation aims which are more novel for the sector and of a larger scope are considered to entail a higher level of innovation uncertainty than those which are less novel and have smaller scope innovation aims (as explained in the theoretical part, the novelty of the aims increases the level of uncertainty about task and demand).

Network heterogeneity. The differentiation of the partnerships along the lines of network heterogeneity was done on the basis of the number of types of partners (typified according to the ISIC list). Table A3.2 in Appendix 3 shows two examples of networks with the ISIC categorisations. The networks differed in size (ranging between 6 and 50 participating organisations) and heterogeneity (ranging between 4 and 25+ ISIC categories). Positioning the projects on a continuum from low to high heterogeneity, a distinction was made between

two globally distinct groups: networks with less than 15 types of organisations, which are less organisationally challenging, and networks with more than 15 types of organisations, which are more organisationally challenging.

Structural governance. As agreements can be made on a contractual (enforceable by judicial/ legal procedures) and extra-contractual basis (enforceable by internal dispute-settlement mechanisms) (Grandori and Furlotti, 2010), a distinction was made between agreements codified in a formal contract (contractual) and informal agreements (extra-contractual) such as those made in project proposals. Appendix 3 Table A3.1 shows a list of agreements which were either codified in a formal contract or agreed in an extra-contractual way. The number of aspects agreed contractually and the number of aspects agreed extra-contractually (through project proposals) were inventoried and used as measures of contractual and extra-contractual formalisation.

The extent of rational commitment is established on the basis of indicators such as time investment, managerial support for the project, ownership of the aims, etc. (see Table A3.1 Appendix 3).

Relational governance. The governance mechanisms, attitudinal commitment and trust, were also established on the basis of indicators and/or statements. For example, attitudinal commitment is indicated by the presence of loyalty among the partners. Trust is established on the basis of indicators and statements about confidence in the intentions and capabilities of the partners (see Table A3.1 Appendix 3).

5.3.5 Analysis

Data analysis consisted of a process of shifting back and forth between the raw data, the patterns emerging from the data, and extant theory on governance of co-innovation. The analysis took an iterative rather than a linear path but for the purpose of simplicity it is presented here in distinct stages.

Step 1. Classification of partnerships

First of all, the measures of innovation uncertainty and network heterogeneity are used to classify the 18 partnerships as introduced in the theoretical part of the paper. The distribution of the partnerships is presented in Figure 5.2. The number of partnerships with high network heterogeneity and high innovation uncertainty is limited. This indicates that the actors from the agri-food sector do not choose en masse to engage in innovations with a high level of uncertainty in partnerships of high network heterogeneity. Innovations with a high level of uncertainty are being undertaken but mainly in networks with limited heterogeneity.

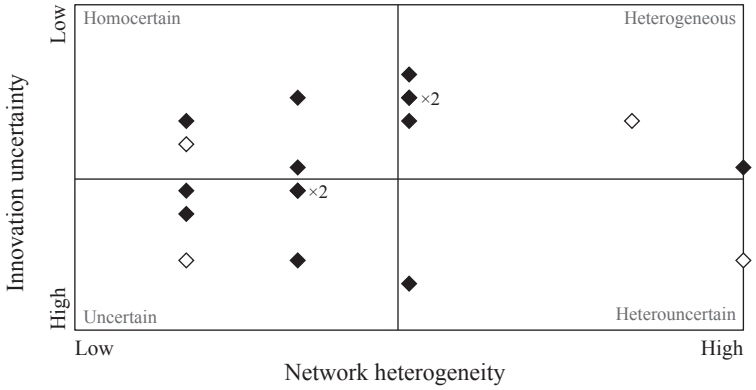

Figure 5.2 *Distribution of partnerships according to the classification in Figure 5.1; the white dots indicate partnerships that were selected for description and discussion in the text.*

Step 2. Case study selection

On the basis of this classification, four cases, representative of each type (see the white delineated dots in Figure 5.2), were selected in order to study in more depth the development of the interplay between structural and relational governance mechanisms. The cases were selected on the basis of their position in Figure 5.2 and the aims of the partnerships, in order to discuss cases representative of the different combinations of innovation uncertainty and network heterogeneity. The goals and level of innovation uncertainty and network heterogeneity per partnership will be discussed at the start of each of the case descriptions below.

Step 3. Analysis events

With the aim of analysing the interplay between structural and relational governance mechanisms which develop over time, one of the analytical steps was to understand and structure key events during the process of co-innovation and analyse the organisational challenges and governance mechanisms used to tackle these challenges. Firstly, detailed case studies were written (Eisenhardt, 1989) portraying different phases in the process, such as the phase before the official start date of the partnership, the first year of the partnership, and the following 3 years of the partnership. These are the general phases of the studied partnerships, but each partnership also had its specific milestones, which were analysed next to the general phases. Next to phases and milestones, the specific organisational challenges were also identified.

Step 4. Analysis relational and structural governance

The fourth step in the analysis consisted of understanding the role of the different structural and relational governance mechanisms which were indicated by the interviewees to have been applied prior to the start, during the first year and after the first year of the co-innovation. Different key concepts from literature were used as indicators of relational governance including rational and attitudinal commitment, compliance and competence trust. Structural governance related to agreements was analysed on the extent to which agreements were used as an anchor point, strict application or without any application. These aspects were analysed in detail in each of the interview transcripts and by comparing this information with meeting notes, evaluation and review reports.

Step 5. Analysis interplay governance mechanisms

In the fifth stage of the analysis, the findings from step 3 and 4 were integrated to understand how the interplay between the structural and relational governance mechanisms was used or applied to deal with the organisational challenges during the different phases of the co-innovation partnerships. For example, for the first year of the partnerships it was analysed to what extent the agreements were used or were deviated from, and whether trust was present and what role it played. Specific events were regarded as milestones where governance mechanisms played an important role in tackling organisational challenges and maximising benefits. The interviewees' information and the analyses revealed where and how the governance failed especially at the stages and milestones where difficulties were encountered in dealing with the challenges in an effective way. This provided input for conclusions about the way in which the complementary roles of the structural and relational governance mechanisms could have contributed to better results. The analysis is completed by studying the weight of structural and relational mechanisms in the different types of partnerships. Mean values from the seven-point Likert scale statements and other scorings (e.g. formalisation) from the 18 partnerships are used to analyse the overall differences.

5.4 Results

In the following part, the way in which the structural and relational governance mechanisms interplayed during the collaboration is discussed on the basis of the four cases indicated in Figure 5.2. The cases are described in a condensed way, focusing on the depiction of the interplay among the different structural and relational governance mechanisms. Hereby, the events and organisational challenges are referred to where necessary to clarify at what stage in the collaboration and for what purpose the role of structural and relational governance mechanisms was important.

5.4.1 Homocertain partnership

The Homocertain partnership was established to contribute to a reduction in pesticide use by identification of a new apple variety resistant to fungal diseases and preferred in taste by consumers. In this case innovation uncertainty was limited because of the potential of the innovation to contribute to the reduction of time-to-market of a new apple variety (reduction of time needed for the breeding process) and lowering of the costs, due to reduction in pesticide use. Due to these advantages, interest among the pip fruit growers for this new breeding technique and a new apple variety was present. The co-innovation partners had less control over the uncertainty related to consumer acceptance of such new products, which were perceived to be genetically modified. The task uncertainty was also limited because two of the partners had already discovered the fungal-disease resistant gene in an earlier DNA-marker research project. The goal in the studied partnership was to isolate or single out this apple gene. Previous cooperation and a limited number of partners made the level of heterogeneity rather limited in this co-innovation partnership. During the four years of this partnership, their network heterogeneity ranged from 3 to 5 types of organisations, including a plant research institute, fruit growers, a consultancy firm and communication experts.

Structural governance - formalisation and application

In this partnership a rather detailed formalisation took place at the start of the collaboration and the limited size of the network enabled the partners to involve everyone in this process. The partners made agreements about the innovation goals and planning, as well as a number of progress assessment criteria (see Figure 5.3 structural governance (formalisation)). The low level of network heterogeneity eased the application of agreements. Also the partnership manager had an important role in the structural governance, through active engagement in the coordination of the collaboration and progress of the innovation process. He was in charge of welcoming new ideas and adaptations, but also critically assessing changes to assure continuance and coherence of the initial innovation aims (see Figure 5.3 structural governance (application)). In this partnership, a number of contractual agreements about investment of resources and property rights were also made. A joint venture was set up, with the plan to use future profits from commercialisation of the new apple variety to continue innovation (see Figure 5.3 structural governance (formalisation)). In order to assure free circulation and mobility of knowledge, agreements concerning the confidentiality and knowledge exchange were also made.

Rational commitment and competence trust

The high interest among the apple cultivators for the development of a new fungal-disease resistant apple variety was motivated by the reduction in the use of pesticides it would bring, and eventually also the costs. This was also the reason for the cultivators to co-invest financially in this innovation. They were continuously kept up to date about the

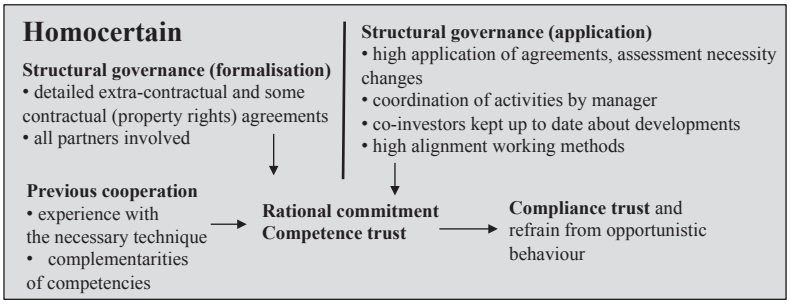

Figure 5.3 *Schematic overview of governance during the collaboration in the Homocertain case.*

developments and achievements in the partnership, so as to ensure and safeguard continuing support and commitment to the innovation. Rational commitment in this partnership was also demonstrated by the fact that the partners were not only *motivated by financial gains, but also passionate about the development process, the goals of the innovation and the potential success.* The support from the growers and the competence trust in the knowledge institute to single out the necessary gene for the fungal disease resistant apple variety were at the basis of rational commitment in this innovation partnership (see Figure 5.3 rational commitment and competence trust). Rational commitment was the self-enforcing drive, making the partners put time and effort into the innovation activities and refrain from opportunistic behaviour. Low rational commitment was present in the case of the partner responsible for the communication and procurement of the innovation in the society and among the consumers to achieve acceptance of this new apple variety, avoiding confusion with genetically modified varieties. In the absence of rational commitment, this partner tried to put in as little effort as possible while sharing in the advantages to a maximum extent.

Previous collaboration and trust, but continued alignment and adaptation

In this partnership, a high level of competence and compliance trust was already present between the pip fruit innovation firm and the plant research institute. It was developed on the basis of previous cooperation where the partners learned much about each other's trustworthiness and compliance with promises and agreements made. This basis of trust made them very confident about the potential success of the innovation partnership. They were aware of the complementary aspects of their skills and resources and the congruence in their working methods, which enabled governance of organisational challenges by trust in this partnership (see Figure 5.3 previous cooperation and competence trust). The attachment of value to their relationship, or in other words attitudinal commitment, made them behave according to the common norms, including compliance with agreements and refraining from opportunistic behaviour. Nevertheless, they remained aware of the need to devote attention to adaptations and changes necessary for this specific co-innovation process. The partnership manager indicated that '*each party saw the valuable contribution of the others which resulted*

in increased contact and communication, turning around their differences into an advantage.' Only the shirking partner turned out to be very unreliable and opportunistic in its behaviour, which eventually led to eviction of thus partner from the partnership. This case indicates that for trust to function as a governance mechanism, a large amount of time is needed for the recognition of similarities and sharing of norms of behaviour, as well as the working methods and approaches. While the build-up process is slow, the process of trust destruction is much faster and easier.

5.4.2 Uncertain partnership

In the Uncertain partnership, the goal was to identify a crop which could be cultivated in saline soil. At the same time, publicity was sought to promote this cultivation method and explore, as well as create interest for brackish-water grown crops and the possibilities thereof. The innovation process in this partnership started with the very first phase of concept and idea development, which led to a high level of uncertainty about the goals which included identifying an appropriate crop for cultivation in brackish water, finding the appropriate cultivation methods and assuring acceptance and usability (market potential) of these crops on a large scale. The heterogeneity in this partnership ranged between 3 to 5 types of organisations, including an entrepreneur who produced environment-friendly products, governmental body for water management, the knowledge institute (faculty of earth and life sciences – subsection systems ecology), plant research and earth and life sciences institute, and a centre for hydrology and water management. With this limited level of heterogeneity of partners, the partnership was mainly marked by uncertainty.

Structural governance (formalisation) and rational commitment

In this partnership, extra-contractual formalisation was low and included only agreements on the major objectives, yearly task division and time investment per partner. At the start of the collaboration structural governance was planned to consist of a steering group and working groups to structure the communication process, joint-decision making and adaptation. However, in practice even the agreements on the task division were not upheld and only the partnership manager and one of the knowledge institutes executed the innovation activities by dealing with the situation as it suited the occasion. Discussion about the property rights did take place, but contractual agreements were never made. Also agreements about financial investments for the product development and marketing phases were not made. This limited attention to the formalisation phase left room for ambiguity and misunderstandings among the partners (see Figure 5.4 structural governance (formalisation)*). The absence of goal alignment prevented clarification of the individual interests and rational commitment (see Figure 5.4 rational commitment unclear*). For 4 out of 6 partners, the potential of the innovation and the possible individual gains from the innovation were insufficiently clear. This inhibited rational commitment which led to the situation where these 4 partners refrained from action and effort towards innovation process progress (see Figure 5.4 rational commitment* and

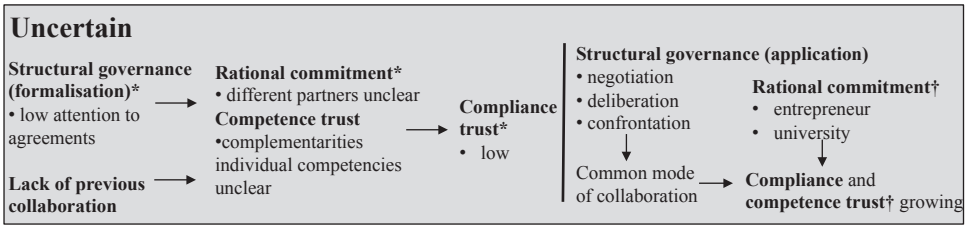

Figure 5.4 *Schematic overview of governance during the collaboration in the Uncertain case.*

compliance trust*). The lack of clarity about the rational commitment complicated the task of the partnership manager to coordinate and guide the activities towards progress.

Rational commitment and compliance trust

Only the environment-friendly products producing entrepreneur and the knowledge institute (faculty of earth and life sciences – subsection systems ecology), who did not cooperate previously, continued the innovation process (see Figure 5.4 rational commitment†). The entrepreneur was personally convinced of the potential of the brackish-water grown crops, but he needed the competencies of the plant, earth and life sciences institute to be able to identify the suitable crop variety and the specific conditions needed to grow crops in brackish water successfully. Convinced that a brackish-water grown crop could be identified and that products containing extracts from these crops would result in successfully marketable products, the entrepreneur put a lot of time and effort into the innovation process. The participating knowledge institute demonstrated rational commitment by the employment of a PhD-researcher to perform the necessary research for the innovation process (see Figure 5.4 rational commitment† and compliance trust†). This case demonstrates the importance of rational commitment, despite setbacks, such as the difficulties with the non-cooperative partners or other problems and obstacles. For example, at some point, the stage of the set-up of an experimental garden testing the growing abilities of a number of crops in different brackish water conditions was reached. However, a bird protection group started protesting against the set-up of the experimental garden with the argument that a protected bird species would be endangered in that specific place. At this point in the process, the high rational commitment of the entrepreneur was the drive for fighting this set-back, assuring that the experimentation could continue. Due to this rational commitment, there was even a willingness to make even additional investments, despite the setbacks which restrained progress.

Growing competence and compliance trust

In the absence of previous collaboration, the entrepreneur and the knowledge institute experienced difficulties with regards to finding commonalities in the working methods. However, after a number of harsh discussions and confrontations, they managed to reach a

number of commonalities (see Figure 5.4 structural governance (application)). For example, their differences were related to the speed in the activities and reaction. The entrepreneur requested that the knowledge institute occasionally finds an answer to practical questions. At the start of the collaboration, the reaction to these kinds of requests took much more time than the entrepreneur had in mind. This resulted in dissatisfaction and disagreement, but after some confrontations and discussions about these kinds of differences, the two partners managed to find a mode of collaboration which suited both sides. Eventually, they managed to build up a level of competence and compliance trust (see Figure 5.4 compliance and competence trust†), but without achieving attitudinal commitment. Despite all of the difficulties, progress and achievements were made, such as the introduction of a number of local crops to the market. In addition, collaboration with a number of high quality restaurants was explored to serve foods grown in brackish water.

5.4.3 Heterogeneous partnership

The aim of the Heterogeneous case was to set up an agro-production and processing park, where industrial production is effectively combined with high standards of animal welfare, high energy efficiency and a low environmental burden. Innovation uncertainty was considered limited because of the knowledge and experience with techniques and processes entailed in the set-up of an agro-processing park. This partnership is mainly marked by the heterogeneity of partners. The heterogeneity of participants ranged between 15 and 17 types of organisations, such as advice and engineering, poultry, cattle and horticultural entrepreneurs, vegetable-processing and eco-energy companies, construction companies, governmental organisations and knowledge institutes. All of these partners had their own goals to achieve through the co-innovation partnership. Due to the differences in disciplines, profession or expertise, differences in terms of knowledge and understanding were abundantly present in this partnership.

Structural governance (formalisation), competence trust and rational commitment

In this partnership, extra-contractual agreements were made with regards to goals, task division and time planning. With the inclusion of partners in the shaping of the aims and goals of the partnership, rational commitment was clear at the start of the collaboration. For example, the entrepreneurs were given room to shape the aims and goals by giving them the possibility to indicate the feasibility of intended initiatives. This assured co-ownership of the innovation process (see Figure 5.5 structural governance (formalisation)).

Despite the heterogeneity and the lack of connection or familiarity on the basis of similar disciplines or professions, competence trust was present at the start of the collaboration in this partnership. This was attained by means of the selection procedure (see Figure 5.5 selection and competence trust*). Each actor was selected on the basis of his/her expertise and experience in the specific field to fulfil the necessary innovation activities and tasks. The initiators of the

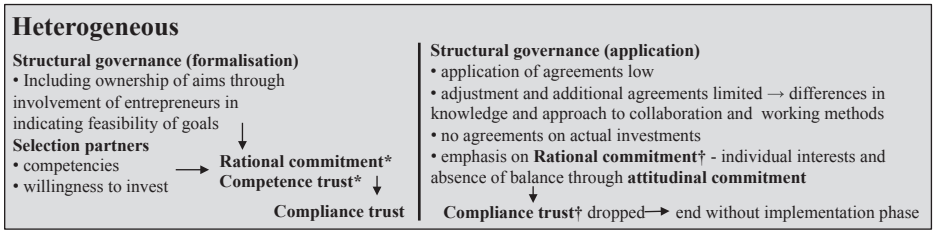

Figure 5.5 *Schematic overview of governance during the collaboration in the Heterogeneous case.*

innovation process embarked upon their network to identify the appropriate partners for the collaboration. One of the criteria was the willingness to invest in the implementation, which was supposed to safeguard the rational commitment and actual investment in the innovation at the implementation phase (see Figure 5.5 rational commitment*).

Structural governance (application) – decreasing rational commitment and compliance trust

The application of the agreements remained limited to agreements about time investment and the rough objectives for the first year. After the first year of the partnership, the partners deviated from the initial agreements and switched to an organic approach to coordination, with emphasis on ad hoc decision-making and problem-solving. Despite the involvement of the entrepreneurs in the shaping of aims and goals, differences in individual interest remained as *one thinks in terms of money, the other in terms of power, and another in terms of reputation* (see Figure 5.5 structural governance (application)). Without much structural governance during the collaboration, alignment of views, knowledge levels about industrial ecology and practical approaches and working methods remained limited. The absence of contractual commitment to the financial investments needed for the implementation phase resulted in difficulties. When the implementation phase was reached, the partners became much more critical and started pushing their own interests, while neglecting the interests and stakes of their partners.

This partnership demonstrates that next to the formalisation process at the start of the collaboration, structural governance requires attention during the collaboration process to assure deliberation and insight about the way in which common goals and actions can contribute to the individual aims of the partners. The absence of using the initial agreements as an anchor point, complemented by changes and adaptations, can decrease the structuring effect of the initial agreements. In the absence of contractual financial commitments at the start of the collaboration, this kind of governance can result in self-interested behaviour. In the Heterogeneous partnership, this brought an end to compliance trust, as partners started to refrain from meeting their obligations and promises and refrained from effort and time engagement into the co-innovation activities (see Figure 5.5 emphasis rational commitment†

and compliance trust† dropped). The result of the partnership was that a Masterplan was developed, but without the implementation of the innovation.

Balance rational and attitudinal commitment

The partnership also demonstrates the interplay between structural and relational governance by pointing to the importance of the complementary role of the relational dimension to the self-interested rational commitment. In a co-innovation partnership, a certain extent of attachment of importance to the relationships (attitudinal commitment) is necessary, because balance between the own interest and the partners' interest must be present to be able to continue the collaboration. Attitudinal commitment, which was not present at the start, did not grow over time, and so did not create any relational incentive to continue compliance with agreements and obligations (see Figure 5.5 absence of balance through attitudinal commitment). Accordingly, the innovation process was stopped.

5.4.4 Heterouncertain partnership

The Heterouncertain partnership was marked by a high level of uncertainty and a high level of heterogeneity. In this partnership, the aim was to develop new product-market combinations related to landscape-conservation, tourism, care and health, in a particular region of the Netherlands. Their goal statement indicates that changes, which contribute to new bearers of the green space, are aimed at. The network entailed more than 18 types of organisations, including regional government, banks, several universities, management consultancy firms, educational institutes, hotels, wellness and beauty centre, hospitals, breweries, farmers producing local products. The goal of changing the perceptions about product-market combinations among a large number of disciplines and actors created a large amount of uncertainty about the outcome. The uncertainty was high, not only because new ideas for actual innovations still had to be developed, but also because this change in the preconditions (the perceptions) for development of new ideas had to take place first.

Structural governance (formalisation)

The ideas and goals of this partnership were based on a study performed by a university and a network-enterprise in the field of urban planning and design (commissioned by the regional government). They identified five themes which offered possibilities for regional development in a particular area of the Netherlands. On the basis of these ideas, research-oriented, conceptual objectives with sub-goals and task division per half a year were defined at the start of the partnership. A steering group, working groups and a core team were established to structure the communication process. With the study as the basis, the formalisation was performed without much deliberation with entrepreneurs, who would eventually have to implement the innovations. Accordingly, they were completely new to the proposed ideas and collaboration possibilities initiated in this partnership. They experienced great difficulty

in envisioning how the new initiatives would become successful and result in a significant gain for them. According to the partnership manager, the problem is not related to '*the lack of possibilities, but to the too large set-up of the innovation partnership, which was not based on the initiative of entrepreneurs, but mainly on the initiative of the regional government and knowledge institutes*.' Absence of initiation by the entrepreneurs is considered as a limitation to the incentive-based rational commitment by the partners who would have to implement the innovation ideas and plans (see Figure 5.6 rational commitment*).

Competence trust and previous cooperation

In addition to the limited rational commitment, and with this compliance trust (see Figure 5.6 rational commitment* and compliance trust*), the lack of progress in the innovation process was also caused by the absence of insight into the complementarities of the different competencies of the partners (see Figure 5.6 previous cooperation and competence trust*). Path-dependency stopped the partners from distancing themselves from their established practices and routines and establishing competence trust in their partners to be able to take up new roles. Competence trust was present in the established tasks and roles but not in a new setting where the partners would assume an unconventional role. Despite 2 large-scale workshops and 5 steering group meetings, the relations among the knowledge institutes, government and entrepreneurs became more laborious because differences in focus, logic and abstraction level remained. The ideas about the approach to the partnership, and the role divisions, between the governmental agencies and business, retained the conventional patterns. Differences with regards to perceptions about innovation and role divisions also remained between the countryside and urban areas. The established ways of informal communication, hierarchy and power-balances impeded a smooth development of new relations, competence trust and attitudinal commitment.

Structural governance (application)

As a consequence of the limited involvement of entrepreneurs in the initiation and set-up of the partnership, there was dissatisfaction with the initial formalisation and level of specificity

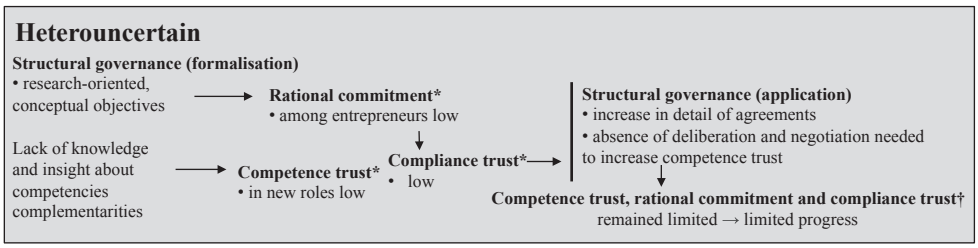

Figure 5.6 *Schematic overview governance during the collaboration in the Heterouncertain case.*

of the aims. Therefore, after the first year of collaboration, the objectives were reformulated in line with the entrepreneurial aims, increasing the level of detail and specification of the sub-goals, activities, deadlines and task division. For example, instead of the 5 themes, only one theme (health, care and cure) was selected as a focus point for development and innovation in the region. Also, it was decided that the partnership would no longer be led by the regional government but by a large regional entrepreneur. However, after a while it turned out that this entrepreneur was in a rather difficult financial position which resulted in bankruptcy. These difficulties entailed in the steering or structural governance of the partnership complicated the progress of the co-innovation process. Also due to these difficulties in the collaboration process, large capital-intensive investments in new plans and innovations remained limited (see Figure 5.6 competence trust, rational commitment and compliance trust†). The partnership did lead to the implementation of a number of innovations. For example, collaboration between hospitals and hotels was established to offer patient recovery arrangements, and an alternative market where regional products are sold was developed.

This partnership demonstrates the importance of the *process of deliberation and negotiation* to increase the level of information exchange about the different interests and views, competencies and possible contributions of the partners to the innovation goal (see Figure 5.6 structural governance (application)). The focus of the formalisation process should not only be on the amount and detail of agreements, but mainly on dialogue and negotiation to increase insight about commonalities and mutual understanding. Instead of strict application of the initial agreements, the use of the latter as an anchor point to deliberate further can increase insight about the complementarities of each other's competencies. This can contribute to the envisioning of the possibilities of new combinations, increasing rational commitment and compliance trust. The absence of rational commitment and compliance trust in this Heterouncertain partnership (see Figure 5.6 competence trust, rational commitment and compliance trust†) was demonstrated by the partnership manager's questioning *how to force people to comply to the agreements made*.

5.4.5 The balance(weight) and interplay between structural and relational governance mechanisms

On the basis of the observations from the 18 innovation partnerships, Figure 5.7 represents the mean scores of the structural and relational governance mechanisms, as well as previous cooperation, per type of partnership classified in Figure 5.1. Results presented in Figure 5.7 show that extra-contractual formalisation is of a medium level (on a scale from 1 to 7 all score 4 to 4.5) in all types of partnerships and that contractual agreements prove to be of a low importance (all score between 0 and 2.8 on a scale from 1 to 7). While the level of extra-contractual agreements does not constitute the main difference among the different types of partnerships, the analysis of the cases above shows that the differences are mainly related to the *process of formalisation* and the *application of the agreements* during the collaboration. When it comes to rational commitment, the observable pattern is that rational commitment is more

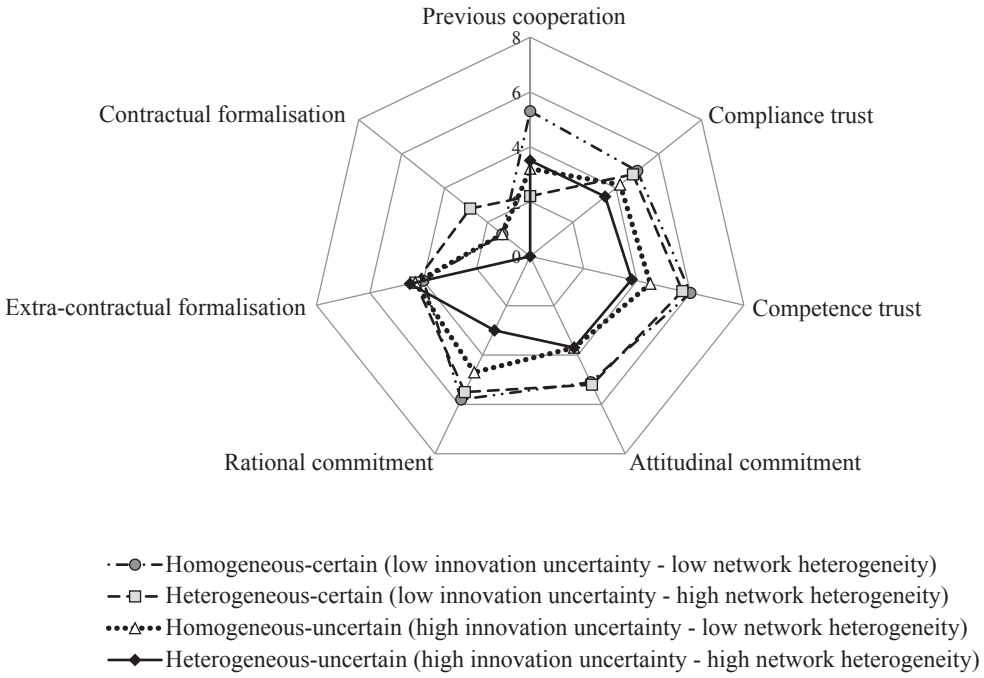

Figure 5.7 *Comparison of means of the 18 innovation partnerships on governance mechanisms per type as classified in Figure 5.1.*

easily distinguishable in conditions of low innovation uncertainty, and that in the second place heterogeneity imposes organisational challenges to rational commitment.

It is difficult to observe a pattern in terms of previous cooperation. This is different in the case of relational governance mechanisms. Figure 5.7 shows that especially competence trust is higher when innovation uncertainty is low, which indicates the importance of trust in the competencies of the partners to be able to deal with the organisational challenges of innovation uncertainty. Also compliance trust is lower in conditions of high innovation uncertainty and it demonstrates resemblance with the pattern of rational commitment, which links these two structural and relational governance mechanisms. Furthermore, competence and compliance trust prove to be impaired by organisational challenges of network heterogeneity, as the latter imposes larger information exchange requirements on the partners to develop trust. Attitudinal commitment shows a pattern of higher commitment in lower innovation uncertainty, which seems to indicate that this relational governance mechanism is somehow related to the calculative incentive, which is at the basis of structural governance.

5.4.6 Innovation uncertainty organisational challenges and the governance mechanisms interplay

The four cases demonstrated that the different organisational challenges are tackled by the interplay between the structural and relational governance mechanisms. The organisational challenge related to uncertainty is the constraint to the ability to plan and the restraining effect on rational commitment which may have an inhibiting effect on compliance to assure progress in the co-innovation. The Heterouncertain case shows in particular how extra-contractual formalisation, competence trust and rational commitment are intertwined. It shows that the most important aspect of extra-contractual formalisation is not the number of agreements made, but the process of formalisation and the use of the initial agreements as an anchor point for structural governance to enhance information exchange about partners' interests (rational commitment) and the possibilities for the complementarities in competencies (competence trust) (see Figure 5.8). This shows that in public-private innovation partnerships the interplay between structural and relational governance mechanisms has an important role, especially with regards to competence trust and rational commitment.

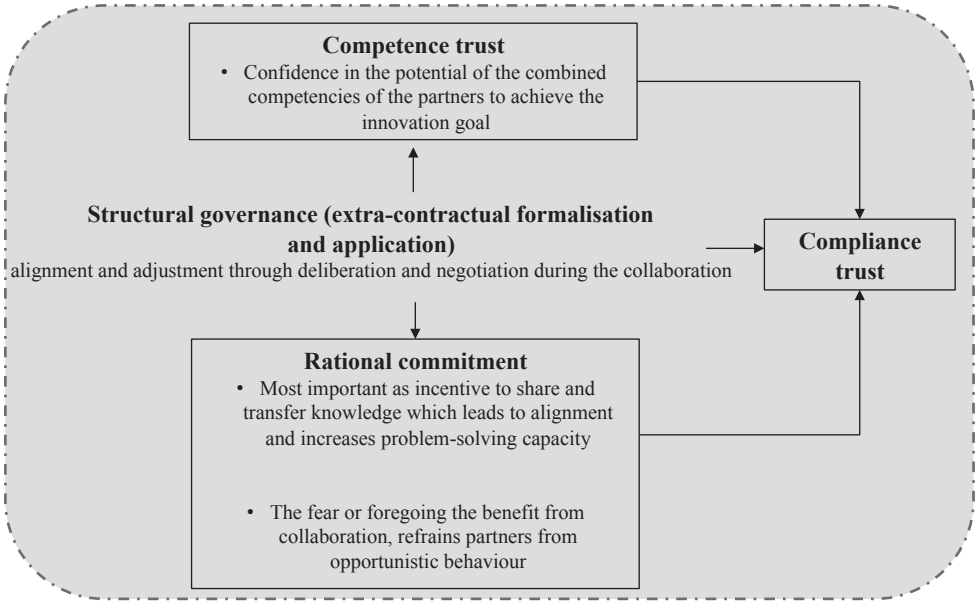

Figure 5.8 *Depiction of the interplay in governance mechanisms on the basis of the 4 cases.*

5.4.7 Network heterogeneity organisational challenges and the governance mechanisms interplay

The general organisational challenge related to differences in interests, views and working methods, as well as the differences in knowledge and understanding (of technicalities, due to differences in disciplines) requires knowledge mobility. Extra-contractual formalisation can play an important role here as well, because it stimulates the partners to reveal and exchange information about their interests, views and goals. This explication and specification of aims clarifies the expectations and extent of rational commitment per partner (see Figure 5.8 extra-contractual formalisation and rational commitment). The Uncertain case shows how the absence of this type of alignment at the start of the collaboration resulted in unclearness about rational commitment, needed to assure progress in the innovation process. Rational commitment is also important for stimulation of knowledge mobility and problem-solving capacity during the collaboration (see Figure 5.8 rational commitment). The presence of rational commitment also creates the incentive for partners to refrain from opportunistic behaviour (see Figure 5.8 rational commitment). In the Heterogeneous case, the low level of attention to structural governance during the collaboration inhibited the alignment of individual interests and goals, knowledge levels and working methods. This led eventually to impairment of the progress of the innovation process.

5.5 Discussion and conclusions

The aim of the present study was to explore the possibilities of structural governance mechanisms in conditions of innovation uncertainty and network heterogeneity to attain effective and efficient innovation partnerships. The exploration resulted in the adaptation of Table 5.1 presented at the start of this chapter, into Table 5.7. This will be explained below.

Table 5.7 *Structural and relational governance mechanisms adapted.*

	Structural	**Relational**
Mechanism	contractual agreements	trust
Incentive	rational commitment	attitudinal commitment
	calculated and self-interested motive	value of relationship as an asset which yields high returns
Adaptation	extra-contractual agreements	mutual orientation; values relations
		acceptance of temporary inequity in relationships

5.5.1 Importance of structural governance mechanisms

In contrast to previous studies which put the emphasis on relational, instead of structural governance (Reuer and Arino, 2007; Reuer *et al*., 2006; Klein-Woolthuis *et al*., 2005; Anderson and Dekker, 2005; Lazzarini *et al*., 2004; Luo, 2002; Poppo and Zenger, 2002; Bachmann, 2001; Zaheer and Venkatraman, 1995; Larson, 1992), the present study shows that structural governance can have an enabling and facilitating role in conditions of uncertainty and innovation. It can assure knowledge mobility and manage appropriation of innovation results (Bleeke and Ernst, 1991; Omta and Van Rossum, 1999; Dhanaraj and Parkhe, 2006), and at the same time constitute the basis for the achievement of commonalities, explication of motives and commitment, and solve coordination problems (Omta and Van Rossum, 1999).

This study shows that in conditions of innovation uncertainty, agreements which are made extra-contractually (Grandori and Furlotti, 2010) can offer the solution. Extra-contractual agreements allow for the necessary adaptation possibilities and flexibility while collaboration is structured through arrangements on a system for communication, joint-decision-making and negotiation (Casciaro, 2003). Extra-contractual agreements, such as job descriptions, rules and procedures, are internally enforceable documents (Grandori and Furlotti, 2010) which can complement court enforceable contractual agreements. Extra-contractual agreements about objectives, tasks, roles and time investment were made in all partnerships. However, the application of these agreements turned out to be rather limited in partnerships where either initial formalisation of interests and goals limited rational commitment or insufficient structural governance took place through application and coordination of the initial agreements. Extra-contractual formalisation can be used to clarify the interest-based incentive, rational commitment and bring structure to the collaboration. Structural governance, through application of agreements, and coordination of the partnership, through additional deliberation and alignment of interests, expectations and knowledge among the partners, remains important during the entire process. Convergence of interests and insight into the complementarities of capabilities and knowledge is important to assure compliance trust and progress in the innovation process.

5.5.2 Intertwined character of structural and relational governance mechanisms

Partner-specific knowledge and acquaintance (Barney and Ouchi, 1986) and socialisation to network-specific culture and norms (Macneil, 1978; Ouchi, 1980) seem to generate compliance trust at the start of the collaboration (Caniëls and Gelderman, 2010), as demonstrated by previous cooperation in the Homocertain partnership. Compliance trust has most governance potential in low network heterogeneity, where circulation in similar flows of knowledge is more probable. However, this is not guaranteed in low heterogeneity, as demonstrated by the Uncertain partnership.

Compliance trust is only a complementary mechanism as absence of sufficient rational commitment to comply with the agreements can overrule the norm-based compliance trust. This is demonstrated by the case with low network heterogeneity and high innovation uncertainty. The incentive to continue the partnership and comply with the agreements made is highly important for the maintenance of compliance trust. In conditions of high innovation uncertainty, it might be the case that the incentive is not large enough to uphold or increase the level of compliance trust.

Rational commitment, and the fear of foregoing the benefits and profits from the innovation, functions as an incentive for partners to abstain from opportunistic behaviour and to put effort into the innovation partnership. This self-enforceable (Grandori, 2006; Baker, Gibbons and Murphy, 2002), incentive-based governance seems to be mainly effective in conditions of lower innovation uncertainty, Homocertain and Heterogeneous types of partnerships. The low innovation uncertainty increases certainty about potential rewards from collaboration and with this rational commitment. The Heterouncertain partnership shows that the combined effect of high innovation uncertainty and high network heterogeneity has an even more disturbing effect on rational commitment, because a high diversity of interests and goals limits the specificity of the agreements and with this the amount of incentive(s) for compliance. The formalisation process and structural governance during the collaboration can help to mitigate this through deliberation and alignment at the start and during the co-innovation process. The exemplification of rational commitment and complementarities of individual complementarities creates the necessary incentive for compliance.

The challenges related to innovation uncertainty about the progress and outcome of the innovation process can be tackled by means of competence trust. However, competence trust is difficult to achieve in conditions of high network heterogeneity, because competence trust requires similarity of partners for understanding about each other's competencies. Firms are more inclined to trust more similar firms and actors, as a similar character is considered to equate to similar attributes, capabilities and expectations (Gulati, 1995). Competence trust requires shared understanding of professional conduct and technical and managerial standards (Sako, 2006). The case with high innovation uncertainty and high network heterogeneity (Heterouncertain) showed how the absence of mutual understanding of the value of individual organisations' contributions in terms of skills, resources and capabilities, prevented the partners from seeing the business opportunities and potential of the innovation. This also impeded compliance trust, which points to the intertwined character of the relationship between competence trust and rational commitment. The former can be a pre-condition for the latter to develop (further). The case with low innovation uncertainty and high network heterogeneity (Heterogeneous) demonstrated that competence trust can be built in heterogeneous conditions, but that it can be very easily damaged. *Involvement of all* the partners in *a detailed extra-contractual formalisation process* and use of the initial agreements as an anchor point for adjustments and additional alignment during the collaboration can

be employed in highly heterogeneous conditions to increase acquaintance with partners' competences and attain a higher competence trust.

Attitudinal commitment as incentive has much less potential in conditions of high network heterogeneity, where there is less potential for personal acquaintance among partners. Attitudinal commitment entails a partnership acquiring a position of status and importance, involving a psychological identification with the relationship and a pride of association with the partner(s). This type of commitment entices additional effort to make the collaboration successful and creates willingness among the partners to go beyond mere contractual obligations (Cullen *et al*., 2000). It also induces additional dedication of resources and risk taking (Cullen *et al*., 2000). This type of commitment is only found in the Homocertain partnership, which demonstrates that attitudinal commitment is built on the basis of communication, exchanges and mutual understanding. The Uncertain partnership shows that innovation uncertainty, affecting rational commitment and compliance impedes development of attitudinal commitment.

While structural governance has limitations, in terms of contractual agreements, structural governance also has flexible elements which bring structure to the collaboration and are to be differentiated from *control*. Relational governance also has its limits, as informal group coordination can show constraints in large group sizes, creating information-processing difficulties and possible conflict of interests among the different actors (Grandori, 1997). It is the interplay between relational and structural governance mechanisms which is most effective. The relational dimensions entailed in trust remain important for governance in innovation partnerships (Thorgren and Wincent, 2011). However, structural adaptation, communication and integration governance mechanisms can complement this by fulfilling the coordination and information-processing requirements (March and Simon, 1958; Simon, 1962; Thompson, 1967; Galbraith, 1977). The structural perspective allows for the necessary adaptation by means of arbitration, internal dispute settlement, and changes to the planning made at the start of cooperation (Paasi *et al*., 2010; Nystén-Haarala *et al*., 2010). In Table 5.7, the governance mechanisms indicated in Table 5.1 are complemented with extra-contractual formalisation which offers this flexibility to structural governance.

Rational commitment (Cullen *et al*., 2000), which is based on calculated self-interest (structural governance) can be complemented by attitudinal commitment (relational governance), or the value of relationship as an asset which yields high returns (Madhok, 1995; Cullen *et al*., 2000), to participate and abide by the agreements made. The relational incentive, attitudinal commitment, complements rational commitment due to the value attached to the relations, as partners develop willingness to adapt to one another's needs and are willing to accept temporary periods of inequity (Madhok, 1995).

6. Discussion and conclusions

The present thesis discusses internal and external capabilities and governance mechanisms that affect innovation performance. Several theories have been employed to shed light on in-house and network-oriented innovation processes. The resource-based view was used to focus on the resources and capabilities required to manage the in-house innovation projects. The knowledge-based and dynamic capabilities views were used to study the external knowledge acquisition through networking and absorptive capacity of companies. Structural and relational governance perspectives provided the theoretical background for the studying and understanding of the interplay among the structural and relational governance mechanisms to improve performance in co-innovation partnerships. Each of the previous Chapters contributes in a specific way to theoretical discussions. In the present Chapter, these will be pointed out, and the results and contributions of the individual research parts will be combined to indicate the overarching theoretical contribution. After the discussion on the theoretical contribution, the methodology, limitations of the study and a number of possible directions for further research, the Chapter will conclude with a number of practical implications of the present study.

6.1 Theoretical contribution per chapter

6.1.1 Innovation, capabilities, innovation potential and performance (Chapter 2)

Research about the success factors for in-house innovation projects is mainly based on empirical studies, such as the SAPHHO study (Rothwell, 1972) and Cooper's pivotal work developing the NewProd assessment tool (e.g. Cooper, 1979, 1987, 1999). An extensive number of studies focused on the collection of a large number of independent variables which affect innovation project performance. These developments in the views on the management of in-house innovation projects remained largely unconnected to theories about firm management, such as the resource-based view. One of the consequences was the predominant focus on the direct relations between a set of independent variables and success or failure of the innovation projects (Cooper, 1999; Lynn *et al*., 1999) without considering the complexity of relations among the different determinants of innovation performance. This also does not cover the complexity and non-linearity of innovation processes.

Despite the increasing emphasis on learning and the possibilities to employ the theoretical ideas from the resource-based view to advance the models on innovation management (such as Cooper's NewProd model), an actual connection to Cooper's model of factors relevant for innovation performance was not made. With the exception of the relations between the organisational aspects of planning and control, innovativeness and newness, and innovation performance (Kleinschmidt *et al*., 2007; Salomo *et al*., 2007; Stockstrom and Herstatt, 2008), limited number of studies made the actual connection between Cooper's model of the

determinants of innovation performance and the resource-based view. The study in Chapter 2 contributes theoretically by building a path model which indicates how the resource-based view concepts, functional and integrative capabilities, relate to innovation-characterising concepts, such as novelty and newness, the superiority and market potential of the innovation, as well as performance of in-house innovation projects. Next to pointing to the way in which resource-based view and research on innovation management are related, the study also contributed to a better understanding of the complexity of direct and indirect relations among the innovation project performance determinants.

Innovation and functional and integrative capabilities

The study in Chapter leads to the conclusion that integrative communication capabilities play a highly important role in dealing with the effects of the innovation newness to the company and novelty and complexity of the innovation. Previous research concludes that team interaction, knowledge sharing and communication have a positive effect on innovation process (Imai *et al*., 1985; Katz, 1982; Zirger and Maidique, 1990; Brodbeck, 2001; Keller, 2001). The study in Chapter 2 demonstrates that frequent communication and effective information transmission enables a comprehensive and more complete understanding of complex inter-related activities (Hackman, 1990), enabling the firm to deal with complexity and novelty in innovation. The study leads also to the conclusion that integrative communication capabilities play an important role in the offsetting of the negative effect of newness on functional capabilities. As previous research established, projects with higher novelty and complexity of design and newness of the process technology require more interaction between problem-solvers engaged in interlinked design tasks (Mathur, 2007). Social interaction converts tacit and explicit knowledge (Nonaka, 1994) and contributes to the integrative capability of the firm to combine the different resources and competences spread through different departments of the company. This means that adequateness of functional capabilities can adapt to the needs of the new project through communication and knowledge exchange.

Indirect relations capabilities and innovation performance

Capabilities of the firm are not directly related to innovation performance, but through a complexity of relations among the innovation potential factors (product, market and project potential). The integrative communication capabilities have the most important role in assuring that products which offer unique benefits to the customer, in terms of improved product quality and reduced costs, are more successful in the market (Zirger and Maidique, 1990; Utterback, 1971, Rubenstein *et al*., 1976, Cooper, 1975; 1983). This indirect effect is achieved by a subsequent positive effect from product potential (product superiority) on market potential. A product that is introduced in response to a growing market has a greater chance of success, because the existing players in the market may not be able to meet the market demand at the quality and reliability levels which are preferred by customers. Also, market potential creates a higher chance of profit and an urge to reduce the time-to-market

to be able to introduce the innovation to the market before the competitors. This opportunity in the market substantiates the finding that the novelty and complexity of the innovation can have a positive effect on product potential and with this a positive indirect effect on innovation performance.

6.1.2 Differences between food and beverages (F&B) and technology-based in-house innovation projects (Chapter 3)

The study in Chapter 3 complements the path model study from Chapter 2. While the path model increases insight about the indirect relations between Cooper's innovation performance determinants, the study in Chapter 3 points to the differences in focus in the F&B and technology-based innovation projects. Most of the previous studies about management of innovation took place in high-tech sectors (Cooper, 1988, 1990; Atuahene-Gima, 1995; Maidique and Zirger, 1984; Parry and Song, 1994; Rothwell *et al*., 1974; Cooper and Kleinschmidt, 1993; Ebadi and Utterback, 1984; Salomo *et al*., 2007; Stockstrom and Herstatt, 2008). However, the context in which the innovation takes place can differ and have consequences for the importance of factors affecting innovation performance (Ortt and Van der Duin, 2008; Hirsch-Kreinsen *et al*., 2007). The study in Chapter 3 contributes to the existing literature on innovation management by indicating the specific factors which distinguish high from low performing innovation projects in the food and beverages (F&B) industry by specifying differences between technology-based industries[21] and mature, medium to low-tech sectors, such as the F&B.

Innovation project newness to the company and functional capabilities

The results from Chapter 3 show that newness or unfamiliarity with technologies or processes entailed in the innovation project is one of the obstacles to innovation project success in the F&B companies. The study shows also that specifically functional upstream capabilities (engineering, resources, management, financial skills and resources) are crucial for the distinction between high and low performing innovation projects in the F&B companies (Pandza, 2005; Hayes *et al*., 1996; Hayes *et al*., 1988; Helfat, 1994; Henderson, 1993; Montgomery and Hariharan, 1991; Stalk *et al*., 1992). These two findings taken together lead to the conclusion that when the project is very new to a F&B company, difficulty is encountered with regards to dealing with the adequateness of upstream functional capabilities. Capabilities to deal with newness can be enlarged through, for example, external orientation and internalisation of resources and capabilities (Martino and Polinori, 2011). There is still room for improvement, as collaborative relationships for the purpose of increasing the amount of available resources and capabilities for innovation are incompletely pursued in the food sector, when compared to other industries (Weaver, 2008; Fortuin and Omta, 2008).

[21] Such as automotive, electronics, semi-conductors or pharmaceuticals.

Market potential

The study in Chapter 3 also shows that market potential increases the likelihood of a successful innovation outcome in F&B less strongly than in technology-based innovation projects.[22] Traditionally, the F&B industry does not have a long track-record of market-pull innovations or involvement of lead users in the innovation process. Previous research established that a lack of concrete guidelines for the effective implementation of consumer-oriented food development, the sequential approach of the innovation process and the lack of intra- and inter-organisational coordination or integration of R&D and marketing know-how (Costa and Jongen, 2006) constitute barriers to innovation in F&B companies. Recent attention to user-oriented innovation (Grunert *et al*., 2008), such as individualized products and short response time (Grunert *et al*., 2008), constitutes promising developments for the F&B industry to improve on the weak factor of market potential.

6.1.3 Organisation of networking and absorption of knowledge for innovativeness (Chapter 4)

Dynamic nature of absorptive capacity

The study in Chapter 4 contributes to the existing literature on knowledge absorption which is based on the developments in the knowledge-based and dynamic capabilities view. Next to the fact that the study in Chapter 4 explores the absorptive capacity within an unexplored area (pig farmers), the study delivers a theoretical contribution by establishing support for the dynamic nature of absorptive capacity. It is found that there is not only a sequential relationship between the potential (acquisition and assimilation) and realised (transformation and exploitation) absorptive capacity, but that there is also a link in the opposite direction. The study shows that the capacity to *transform* knowledge (or facilitate the recognition of opportunities and consequences of new external knowledge) can enhance the (*acquisition*) capacity to allocate the network actors who can provide the knowledge about innovations in the sector. This is in line with Zahra and George's statement that '*absorptive capacity follows a multidirectional and fluid path, rather than a patterned trajectory of knowledge acquisition and exploitation*' (Zahra and George, 2002, p. 198). The study in Chapter 4 also shows that exploitation capacity is most strongly related to profitability. This is supportive of the conclusion by previous research that '"*realized" absorptive capacity approaches the "potential" absorptive capacity in firms with a high efficiency factor* (Grant, 1996). *Given that profits are primarily created through realized absorptive capacity*' (Grant, 1996; Zahra and George, 2002, p. 191), knowledge acquisition should be exploited to result in return on investment. Firms should find a balance between acquisition and exploitation.

[22] The same result can be observed for the integrative communication capabilities. However, this is not statistically significant.

Organisation of networking behaviour as element of absorptive capacity

Next to the analysis of the non-sequential/dynamic nature of absorptive capacity, the study in Chapter 4 also addresses the relation between the *organisation of the networking behaviour* and absorptive capacity. The study addresses the neglected potential of *organisational capabilities* to absorb knowledge, in studies with a social network perspective. The study in Chapter 4 addresses this gap by suggesting that the networking frequency within a wide network range[23] (Granovetter, 1982; Krackhardt, 1992; Burt, 1996, 2005; Reagans and McEvily, 2003) reflects one part of the intensity and direction of efforts of the firm to access external information (Zahra and George, 2002). The other part reflecting the intensity and direction of efforts to acquire external information consists of the organisational aspects entailed in acquisition, such as identification of the most important knowledge sources, discussion with business partners and participation in sector meetings (acquisition capacity). The study shows that these aspects have a positive effect on the assimilation capacity (ability to understand and recognise relevant changes and possibilities). It is concluded that frequency of contact in a specific network range affects innovativeness positively, but also indirectly through acquisition and assimilation capacity. A proactive and strategic approach towards absorption of knowledge and use of the network is needed to assure that sufficient interest and dynamism is created to induce change.

6.1.4 Interplay governance mechanisms in co-innovation partnerships (Chapter 5)

The study in Chapter 5 contributes to existing literature by demonstrating the advantages and necessity of structural governance mechanisms. Instead of the assertion that socially defined, norm-driven definitions of proper behaviours can substitute formalised definitions of these norms (Grandori, 2006; Lampel, 2004; Caniëls and Gelderman, 2010), the study in Chapter 5 demonstrates that the interplay between structural and relational governance mechanisms is especially important to deal with the organisational challenges in co-innovation partnerships.

Extra-contractual formalisation explicates rational commitment and induces competence trust

The study demonstrates the structuring value of *extra-contractual agreements* (Grandori and Furlotti, 2010) which can reduce uncertainty entailed in innovation to a certain extent. The making of extra-contractual agreements constitutes the basis for the achievement of commonalities, explication of motives and commitment, and solving of coordination problems (Omta and Van Rossum, 1999). The structuring effect turned out to be rather limited in partnerships where either insufficient attention was given to the initial formalisation process of interests and goals created restraints on rational commitment, or where insufficient structural governance took place through application and coordination of the initial agreements. The

[23] See Footnote 7 in Chapter 4 for an elaborate explanation of networking frequency within a wide network range.

process of formalisation and information exchange at the initial stage is more important than the number of agreements. Involvement of all the partners in a detailed extra-contractual formalisation process, and use of the initial agreements as an anchor point for adjustments and alignment can contribute to acquaintance with partners' competences and higher competence trust in heterogeneous conditions. This interplay between extra-contractual formalisation and competence trust can contribute to efficiency through structure, while at the same time it can offer the necessary flexibility.

Compliance trust complementary to rational commitment

Compliance trust has the most governance potential in low network heterogeneity. However, compliance trust is only a complementary mechanism as absence of sufficient rational commitment to comply with the agreements can override the norm-based compliance trust. This is demonstrated in the study in Chapter 5 by the case involving low network heterogeneity and high innovation uncertainty. In conditions of high innovation uncertainty, it might be the case that the incentive is not large enough to uphold or increase the level of compliance trust.

Rational commitment entices attitudinal commitment

Attitudinal commitment is only found in the low innovation uncertainty and low network heterogeneity partnership. However, in this partnership rational commitment, or an initial level of potential pay-off from the relationship, induced attitudinal commitment to develop. Cullen *et al*. (2000) also state that relational investments, building attitudinal commitment, must begin with the practicalities of the business relationship. However, they also point out that previous research demonstrated that predominance of calculative/rational commitment, without the attitudinal component, may be detrimental to the relationship (Kumar *et al*., 1994). The conclusion from the study in Chapter 5 is that the balance between attitudinal and rational commitment is important in order to attain a fruitful and efficient collaboration outcome (Cullen *et al*., 2000).

Competence trust as precondition for rational commitment which encourages compliance

The challenges related to innovation uncertainty about the progress and outcome of the innovation process can be tackled by means of competence trust. However, network heterogeneity imposes obstacles to competence trust which requires a shared understanding of professional conduct and technical and managerial standards (Sako, 2006). The case with high innovation uncertainty and high network heterogeneity in Chapter 5 showed how the absence of understanding of competencies' complementarities, limited rational commitment and compliance trust. Competence trust can thus also be a pre-condition for rational commitment to develop (further) and encourage compliance.

6.2 Overall theoretical contribution

The main aim of the current study is to contribute to the existing literature on innovation management by embarking on the resource-based view, the knowledge-based and dynamic capabilities view on absorptive capacity, and the structural and relational governance perspectives. The study provides insight into the internal and external capabilities (Verona, 1999) which are important for innovation performance, in-house and in network interactions or co-innovation constellations.

6.2.1 Internal capabilities (in-house innovation)

The resource-based view was used as the theoretical background for the internal functional and integrative capabilities (Verona, 1999). Functional firm capabilities emerge from integration and combination of resources (Peteraf, 1993; Prahalad and Hamel, 1990; Wernerfelt, 1984). As demonstrated in the studies in Chapters 2 and 3, functional capabilities, which result from the knowledge, skill and experience of employees, play an important role in the context of innovation (Pandza, 2005). These can be upstream capabilities, such as technological, product development, production process and manufacturing capabilities which allow a firm to differentiate and innovate (Day, 1994; Hayes *et al*., 1996; Hayes *et al*., 1988; Helfat, 1994). Downstream functional capabilities, which involve sales and distribution skills and resources, advertising and promotion, as well as marketing research skills and resources, allow a firm to respond swiftly to changing customer needs, to exploit its technological strengths most effectively and implement effective marketing programs (Day, 1994; Desarbo *et al*., 2005). Previous research within the resource-based view touched upon innovation from a strategic point of view or by framing capabilities in a dynamic context, such as Kleinschmidt *et al*. (2007) who address the evolutionary and dynamic character of the firm capabilities through skill acquisition, learning, and accumulation of organisational and intangible assets over time (Teece *et al*., 1997). However, the functional firm capabilities have not been specifically related to innovation-characterising aspects, such as innovation novelty and newness of the innovation project to the company (Cooper *et al*., 1989, 1993). The present study addresses this gap in Chapter 2 by linking innovation-related factors to functional capabilities.

Next to the functional capabilities, the integrative capabilities are also linked to the innovation literature, in terms of determinants of innovation performance (Cooper *et al*., 1989, 1993). Process-related, integrative capabilities bind different functional capabilities (Pandza, 2005) and contribute to problem-solving through communication. The findings from the study in Chapter 2 show that the integrative, communication capabilities are most important for the product potential of innovation. Novelty and complexity of the innovation project trigger the integrative, communication capability to increase the problem-solving capacity of the innovation team (Brown and Eisenhardt, 1995, Thamhain and Wilemon, 1987; Thamhain, 1996). This increases the chance that problems encountered due to the novelty and complexity of the innovation will be solved and a superior product is created which enhances the potential

of the innovation on the market. While newness of the innovation project is negatively related to the adequateness of the functional capabilities, the integrative communication capabilities are positively related to the adequateness of the functional capabilities (Iansiti, 1997; Pisano, 1994). This indicates that the integrative communication capabilities have the potential to off-set the negative effect of innovation project newness to the company.

6.2.2 External integrative capabilities (networking and knowledge absorption)

Innovation performance is further determined by the capability to engage in and make use of knowledge-sharing routines and complementary resources, skills and knowledge of external firms and organisations (Dyer and Singh, 1998; Verona, 1999; Lewin *et al*., 2011). This points to the importance of the capability of the firm to organise its knowledge acquisition and assimilation processes in such a way as to make use of and exploit it to improve its innovation performance. Lewin *et al*. (2011) distinguish a set of external absorptive capacity *meta-routines and practiced-routines*. One of the externally-oriented absorptive capacity practiced routines entails networking with external firms and organisations (Koch and Strotmann, 2008). The study in Chapter 4 embarked on this practiced routine specifically and focused on the organisational *capabilities* to engage in networking and absorb knowledge from external firms and organisations. The study results in the conclusion that the external integrative capability (Verona, 1999) of the firm ought to be directed at identification of actors which constitute the most important sources of knowledge, frequent contact with a confined number of actors from the network and participation in sector meetings. The capability of the firm to organise this is most important for the assimilation of external knowledge by the firm (Jansen *et al*., 2005[24]). The study finds support for frequent contact (as one of the indicators of strong ties (Granovetter, 1982; Krackhardt, 1992)), as an important relational trait which enables transfer of knowledge and information entailed in innovation (Hansen, 1999, Reagans and McEvily, 2003, Krackhardt, 1992, Uzzi, 1997, Van Gilsing and Nooteboom, 2005, Nooteboom *et al*., 2007). It also finds support for the conclusion from previous studies that capacities to absorb and transfer knowledge are built through maintenance of a diversity of network ties (Reagans and McEvily, 2003; Burt 1992, 2005, Rosenkopf and Nerkar, 2001). A diversity of knowledge sources can enhance the assimilation capacity of the firm in terms of the ability to recognise technical, regulatory, market and demand changes. Next to the capacity to organise frequent networking within a confined network of external firms and organisation, the study also contributes to existing research by identifying that transformation capacity also increases the ability of the firm to assess which external actors constitute the important sources of knowledge to increase the assimilation capacity. The study in Chapter 4 integrates the organisation of networking behaviour into the definition of absorptive capacity as organisational capability. It specifies the frequency and range of networking and organisational capabilities of acquisition,

[24] Organizational mechanisms associated with coordination capabilities (cross-functional interfaces, participation in decision making, and job rotation) primarily enhance a unit's potential absorptive capacity. Organizational mechanisms associated with socialization capabilities (connectedness and socialization tactics) primarily increase a unit's realized absorptive capacity (Jansen *et al*., 2005).

assimilation, transformation and exploitation (Zahra and George, 2002) as the external capability of *networking with external firms and organizations* (Koch and Strotmann, 2008; Lewin *et al*., 2011). The latter is part of Lewin's *et al*. (2011) meta-routine of learning from and with partners, suppliers, customers, competitors, and consultants.

6.2.3 Governance mechanisms in co-innovation partnerships

In the present study, we embark on another of the external absorptive capacity *practiced routines*, identified by Lewin *et al*. (2011), which are the co-development relationships (Dyer and Singh, 1998, Koza and Lewin, 1998). Here, we address the question of how innovation can be facilitated through governance mechanisms. This extends the research on organisational capabilities for the purpose of knowledge absorption (absorptive capacity) by pointing to the potential of organisational governance mechanisms to facilitate knowledge exchange for the purpose of cross-company long-term-oriented sector changes and innovation. Jansen *et al*. (2005)[25] identify a number of organisational mechanisms associated with combinative capabilities which facilitate knowledge absorption. Jansen *et al*. (2005) establish relations between coordination (cross-functional interfaces, participation in decision-making and job-rotation), systems (formalisation and routinisation), and socialisation (connectedness and socialisation tactics) capabilities and the different dimensions of absorptive capacity. In the present thesis (in Chapter 5), the relationship between the structural (e.g. formalisation) and relational governance (e.g. trust) mechanisms and the organisational challenges to co-innovation partnerships are studied. The study increases insight about the way in which knowledge mobility and network stability (Dhanaraj and Parkhe, 2006) can be facilitated to enhance cross-firm, long-term-oriented innovation goals/performance. The conclusion is that extra-contractual formalisation (Grandori and Furlotti, 2010) of aims and planning constitute the basis for the achievement of commonalities, explication of motives and commitment, and the resolution of coordination problems (Omta and Van Rossum, 1999). Sufficient convergence of interests is needed to assure that each partner can recognise his/her own interests in the aims of the partnership and acquire incentive-based rational commitment. Extra-contractual formalisation can be used as a 'tool' to clarify rational commitment and bring structure to the collaboration.

Compliance trust can play a role in the implementation of the agreements made. However, it is challenged by innovation uncertainty. Attitudinal commitment, as the relational incentive, may constitute part of the motivation for the partners to attribute time and resources to the actions and activities which will assure progress of the innovation partnership. However, it is challenged by network heterogeneity, because relationship building and attitudinal commitment require time and information exchange, as well as acquaintance, to develop. These relational governance mechanisms require rational commitment to develop, and are complementary to the structural,

[25] Jansen *et al*. (2005) also point to the organisational capabilities, defined as combinative capabilities (Kogut and Zander, 1992), which companies need to be able to synthesize and apply current and newly acquired external knowledge (Eisenhardt and Martin, 2000; Kogut and Zander, 1992).

self-interest-based incentive. The relational governance mechanism competence trust requires insight about the complementarities of individual competencies. This insight can help to envision the possibilities for the innovation outcome, which means that competence trust can be a pre-condition for rational commitment to develop (further). Extra-contractual formalisation can be used to exchange and acquire more information about each other's competences, increasing (or at least determining) competence trust.

The studies in Chapters 2, 3, 4 and 5 address different theoretical perspectives in order to result in a list of complementary capabilities and governance mechanisms which can assist companies to enhance innovation performance through in-house innovation, absorption of external knowledge through networking with external firms and organisations and governance of co-development partnerships (see Figure 6.1). The conclusion is that next to the internal functional and integrative capabilities (Pandza, 2005; Grant, 1991; Henderson and Cockburn, 1994), external capabilities are also important for innovation performance (see Figure 6.1). Internal capabilities include functional upstream and downstream capabilities, but even more important are the integrative capabilities, such as (team) communication. External integrative capabilities entail frequent networking within a confined network of actors and acquisition through identification of the most important sources of knowledge and participation in sector meetings to increase assimilation capacity and with this the level of innovativeness of the firm.

Next to integration of knowledge, innovation performance is also enhanced through the ability to reap the benefits of cross-company innovation. As example 2 in the introduction indicates, the changes and innovations which have been achieved through collaboration in partnerships may benefit a large number of companies. The study in Chapter 5 shows that co-innovation benefits can be maximised through employment of the intertwined structural

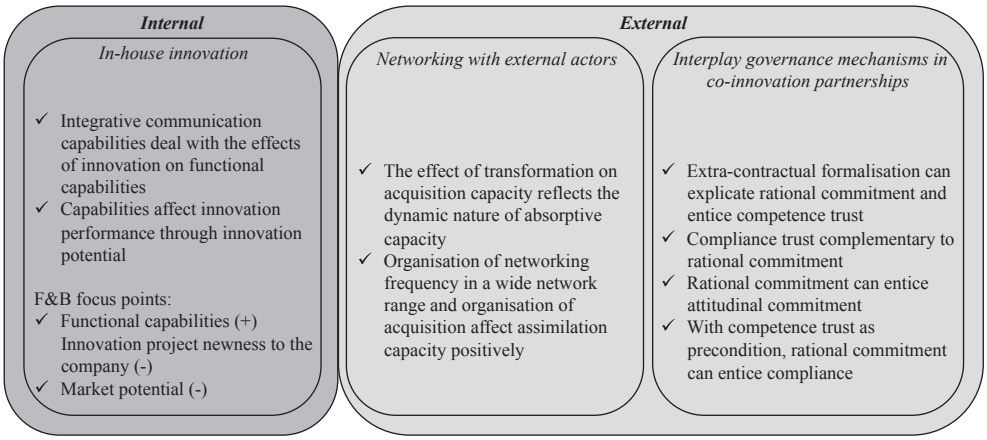

Figure 6.1 *Internal and external capabilities and governance mechanisms.*

and relational governance mechanisms. Especially because innovation and collaboration are dynamic processes, the complementing character of extra-contractual formalisation, rational and attitudinal commitment and compliance and competence trust is needed throughout the process to assure knowledge mobility and network stability (Dhanaraj and Parkhe, 2006).

6.3 Methodology

The contributions from the methodological point of view are multiple. The analyses in Chapters 2 and 4, Partial Least Squares (PLS) and structural equation modelling with Lisrel, enabled the analysis of complexity of internal and external capabilities which aid the use of knowledge to enhance the problem-solving capacity for innovation. Logistic regression, in Chapter 3, complements the study in Chapter 2 by explicating the specificities regarding the internal firm capabilities for the agri-food sector. The external capabilities' focus on knowledge acquisition, assimilation and exploitation for the purpose of the firm benefit is extended by focusing on the understanding of the way in which governance mechanisms can be employed in co-innovation partnerships to increase simultaneously the gains for the companies, as well as for the sector. This understanding is deepened through the case study in Chapter 5 which allowed the exploration of the interplay of governance mechanisms during the co-innovation process. The specific contributions from the methods used, together with the methodological issues and limitations, will be discussed in the following section.

6.3.1 PLS and logistic regression

In the study in Chapter 2, the Partial Least Squares (PLS) analysis contributed specifically to the understanding of the complexity of relationships among a set of independent variables which directly affect the dependent variable of innovation performance. PLS analysis offers the possibility to work on the optimisation of the measurement and structural model at the same time, while building a path model of relations. In Chapter 3, logistic regression complements the PLS analysis by finding out where the focus should be laid among the determinants of innovation project performance in F&B innovation projects, in particular. In Chapter 3, results from logistic regression are combined with insights from desk-research about the innovation status quo in the F&B sector to conclude on the differences in innovation (management) of technology-based and F&B innovation projects. In both chapters, the use of Likert-scale items which echo a perception or attitude (Bollen, 1989) added value to the research because it enabled the capturing of intangible aspects, such as the adequateness of the functional capabilities and the integrative, communication capabilities of the firm.

The downside of the perceptions-based measurements is the possibility for bias (because statements are rated on the basis of subjective assessments). This issue is tackled in the studies in Chapters 2 and 3 by asking four to five innovation members per project to complete the questionnaire. Furthermore, control variables are included in the model, to control for effects

which are due to differences between technology-based vs. F&B innovation projects, size of the company and number of respondents per project.

Another methodological challenge was the fact that the analysis is performed at the respondent level, while the dependent variable, innovation performance, is at the project level. In Chapter 2, the reliability of results is established through the bootstrapping technique in PLS, which includes repetition of calculation of outcomes on the basis of re-sampling. In Chapter 3, clustered error correction per project is used to correct for the assumption that each of the data-points is independent. The clustered error takes into account the interclass correlation and inflates the standard errors, leading to more accurate results.

6.3.2 Structural equation modelling with Lisrel

The application of structural equation modelling in the study in Chapter 4 added value, because it provides the possibility to test the relationships between networking, different dimensions of absorptive capacity and innovativeness and profitability, all at the same time. Also, the method provided suggestions for improvement of the fit. The proposed changes to the model, such as the addition of another relationship between transformation capacity and acquisition capacity, enhanced the comprehension of the existing relations. It pointed to the dynamic character of absorptive capacity. The structural equation modelling is complemented by the analysis of specific actors from the network. This deepened the specificity of the insight into the way in which pig farmers organise their networking interaction.

The goal of the research in Chapter 4 to focus on pig farmers made the measurement of innovativeness very specifically tailored to innovativeness among pig farmers. The question of whether another model would be found if innovativeness were to be measured on a different basis than investment in such stable innovations can be addressed by future research. The applicability of the model in Chapter 4 can be tested in other contexts to establish its generalisability. Furthermore, the innovation performance variable in Chapter 4 consists of the level of innovativeness attained by the farmers, and the level of profitability of the firm which is established on the basis of a number of 7-points Likert scale statements. These measures can be complemented by additional indicators, such as return on investment per specific type of innovation.

6.3.3 Case study exploration

The explorative focus on the interplay between structural and relational governance mechanisms in innovation co-partnerships in the study in Chapter 5 guided us to adopt a specific approach for the analysis of data. The exploration of the presence of both types of governance mechanisms in 18 innovation partnerships is complemented with in-depth study of four specific cases. This type of study design was most appropriate for studying the interplay between structural and relational governance mechanisms during co-innovation processes.

The methodological limitation to the study in Chapter 5 is related to the lack of longitudinal primary data. The interviews were set up in such a way as to analyse the data in an event-based way. Also background documents, such as project proposals, evaluation reports and meeting notes were used to analyse the development of the innovation and collaboration processes in the four cases in Chapter 5. However, the issue remains that no longitudinal primary data have been collected. Therefore, a future study could either focus on this limitation by means of the long-term observation and collection of data from a number of cases or a large-scale longitudinal survey which takes this temporal aspect into account. In addition, in the studied partnerships in Chapter 5, performance is established on the basis of a collection of performance indicators, combining innovation goals, project performance and cross-company performance measures. A future study should focus specifically on the establishment of a rigorous measurement of performance for such co-innovation partnerships.

6.4 Directions for further research

In the following section, possible directions for further research will be briefly discussed.

6.4.1 Internal capabilities - tacit and dynamic nature of organisational mechanisms

Further research can complement the internal functional and integrative capabilities addressed in Chapters 2 and 3 by additional focus on the role of organisational routines in in-house innovation project performance, such as the internal (meta-) routines of absorptive capacity (Lewin *et al*., 2011). These internal meta-routines include facilitation of variation through, for example, solicitation of scientists and engineers to propose and pursue innovative ideas or rotating council of peers to select exploratory projects (Lewin *et al*., 2011). Another internal meta-routine consists of internal selection regimes to enable emergence of new ideas and selection of ideas for further development (e.g. autonomy of middle management to support and allocate resources to projects) (Lewin *et al*., 2011). As already mentioned, the studies in Chapters 2 and Chapter 3 used perception-based items to establish aspects such as integrative communication capabilities. Future research could also take a number of other measurements into account, such as the amount of time devoted to discussion and brainstorming, or the frequency of meetings and discussions among the scientists, production and marketing employees, to establish the more objective measurement of interaction and integration of knowledge. Combination of both types of measurements offers the largest amount of information. In addition to the tacit, the dynamic nature of capabilities also imposes requirements for further research. For example, the study in Chapter 2 shows that integrative capabilities have a positive relationship with functional capabilities. The dynamic character of the interaction between these capabilities was not the focus of the present study, but remains an interesting area for future research.

6.4.2 External capabilities

The firm capabilities which are oriented towards the integration of external knowledge can be further elaborated in future studies through additional focus on organisational capabilities and mechanisms. Future research can put additional emphasis on the routines in organisations and firms to absorb knowledge. Lewin *et al*. (2011) provided an overview of the specific organisational routines which can be used by companies to absorb knowledge from external sources. These include identifying and recognising value of externally generated knowledge (through e.g. mining patent literature and industry magazines, or informal interactions with industry actors) and learning from and with external partners (through e.g. co-development relationships, or collaboration with lead-users or suppliers).

Next to additional focus on the capabilities and organisational mechanisms to integrate external knowledge for the purpose of enhancing the level of innovativeness in the own firm, future studies can consider a larger spectrum of aspects which affect the innovativeness of pig farmers. As previously mentioned, the learning and entrepreneurial orientation, the organisational requirements attached to the type of innovation in which a farmer engages, as well as the financial capacity of the farmer can be taken into account in future studies as determinants of innovativeness.

6.4.3 Interplay governance mechanisms

The emphasis in Chapter 5 was on the exploration of the way in which interplay between structural and relational governance mechanisms are used to deal with the organisational challenges inherent to innovation uncertainty and network heterogeneity. This exploration can be elaborated by future research by evaluating specific coordination costs of structural and relational governance mechanisms, over time, to attain the most effective and efficient outcome. For example, in-depth case studies can be performed which focus specifically on the level of performance measurement in the co-innovation process. A comparison can be made between an effective and efficient, and a non-effective and non-efficient co-innovation partnership. In this comparison, the relationship between the structural governance coordination costs (e.g. created by the active management of the process by a partnership manager) and the extent of compliance and progress in the innovation process (e.g. adherence to task division or time and effort attributed to progress in the innovation process) over time can be studied. A second relationship which should be studied in this context is that between relational governance (e.g. trust/attitudinal commitment) and the extent of compliance and progress in the innovation process over time. Such a longitudinal in-depth study can be used to evaluate the extent to which, and at which points in the co-innovation process, structural governance (in the form of coordination by partnership manager) and relational governance (trust/attitudinal commitment) are the most efficient to attain an effective outcome. Such studies can also be performed by matching the structural and relational governance mechanisms to compliance

in case of different levels of asset specificity (e.g. human capital investment in the research question) to attain effective outcomes efficiently.

Furthermore, future studies can elaborate on the study in Chapter 5 by testing the relationships between innovation uncertainty and network heterogeneity, and the structural and relational governance mechanisms on the basis of a large-scale database. For example, the relationships between innovation uncertainty and different aspects of structural governance, including the types of agreements and formal and informal coordination mechanisms and incentives, can be tested, with successful and failed co-innovation partnerships as a control variable.

6.5 Practical implications – management and governance factors

The studies resulted in several practical implications and lessons. Different actors from the agri-food chains can draw lessons from the current studies, but some of the conclusions may also be useful for other actors, such as the governmental institutions which support innovation in the agri-food sector.

The study in Chapter 2 mainly provides lessons for managers and team members that participate in innovation projects where multiple functions/functionalities (R&D, production, marketing) are represented. The study indicates how the functional and integrative capabilities of the firm are affected by the factors related to the innovation project, how these capabilities impact upon each other and eventually upon the innovation project performance. The study shows that managers should pay specific attention to the adequateness of functional capabilities, in terms of upstream and downstream skills and resources, in case of projects which are very new to the firm. The management can stimulate and organise the integrative, communication capabilities in such a way as to increase the level of knowledge exchange among the team members in the project, increasing the insight about adequateness of different functional capabilities and the problem-solving needed for innovation potential. These findings indicate that adequateness of skills and resources is not *per se* a sufficient condition for achieving high innovation project performance. The role of integrative, communication capabilities in the combination of the different functional knowledge, skills and resources and increase in the problem-solving capacity is most important for innovation potential, and with this innovation project performance.

Furthermore, the study leads to the conclusion that novelty and complexity is an important aspect of the innovation potential, as it influences product potential directly and indirectly through integrative, communication capabilities. Product potential (or superiority of the product) is important because it contributes significantly to the market potential, and eventually innovation performance. The implication for management of innovation projects is that they should not shy away from the novel and (technologically) complex innovations, but ensure that the integrative, communication capabilities contribute to the problem-solving capacity of the team to deal with complexity in novelty. Table 6.1 gives a short overview of the main implications from the study in Chapter 2.

Table 6.1 *Short overview of recommendations for in-house innovation projects.*

In-house innovation projects including multiple functionalities
• The capacity to combine different functional knowledge and skills and increase the problem-solving capacity makes the integrative communication capabilities a main determinant of product potential/ superiority which enhances innovation project performance.
• Novelty and complexity of the innovation should not be avoided because they contribute to innovation product potential. The focus should be on assuring that the integrative communication capabilities contribute to the problem-solving capacity of the innovation team.

The study in Chapter 3 focused on the differences between technology-based innovation projects and those from the F&B industry which leads to a number of practical implications for managers from the F&B industry in particular. The results show that newness of the innovation project to the company and market potential are the weak points in the F&B industry. New projects to the company create a challenge for the adequateness of the functional capabilities. This is especially a problem for F&B companies, where there is already a lower level of investment in R&D. However, there are recommended solutions to this problem. As Ziggers and Henseler (2009) found, F&B companies can engender sustainable competitive advantage by fostering close working relationships with a limited number of partners, building effective network structures and developing a long-term orientation (Ziggers and Henseler, 2009). In collaboration with the partners from the chain, the F&B companies enlarge their access to the pool of information, knowledge and resources, and acquire a better position from which to build a balanced innovation project portfolio including radical (long-term, large-risk) and incremental (short-term, lower-risk) innovations. Engaging in radical, more novel innovation can contribute to sophisticated solutions for customer problems which existing products cannot solve, increasing the product superiority and market potential of the innovation.

The relatively recent focus on more user-oriented innovation and increasing attention to the rising demand for customised products, short response time, and adjustment to the new market needs or technological opportunities (Grunert *et al*., 2008) also offer the possibility for F&B companies to improve the market potential of their innovation. For food processing companies, the potential for the largest gains is related to focus on collaboration with their buyers, which are in this case represented by retail. The absence of actual co-innovation also holds for the information about consumer preferences for innovation in foods. The integration of knowledge and resources from the F&B companies and retail could result in a win-win situation by offering exclusive products which respond to the high sustainability and food quality and safety requirements of the customers. Table 6.2 gives a short overview of the main implications from the study in Chapter 3.

Table 6.2 *Short overview of recommendations for in-house innovation projects in F&B companies.*

F&B companies
• Through collaboration with supply chain partners, companies from the F&B industry can enlarge their pool of resources and capabilities to deal with their weaknesses related to innovation project newness to the company.
• F&B companies could further improve their innovation market potential with more co-innovation with retail, creating a win-win situation by focusing on the high sustainability and food quality and safety customer preferences.

The conclusions from Chapter 4 are specifically relevant for pig farmers, but also for those actors who would like to stimulate the learning and innovativeness level of farmers to increase the level of innovativeness in the chain. Frequency of contact with actors from the network contributes directly to the innovativeness of farmers. The more efficiency-oriented innovations in the field of people, planet and profit require maintenance of contact with a larger number of actors from the network, including the innovation centre Sterksel and breeding farms, but also retail, governmental and knowledge institutes, animal welfare and environment-oriented organisations, such as *Milieudefensie* and Stichting Natuur en Milieu. The farmers who innovate mainly towards pig welfare have a somewhat less elaborate network which is concentrated to most frequent contact with Innovation Centre Sterksel, breeding farms and retail. The greater interest in efficiency in general may be the reason why the planet and people innovators explore more possibilities in a wider network.

Assimilation capacity is the most important dimension of absorptive capacity which increases the level of innovativeness of farmers. Assimilation is affected by acquisition capacity, which entails the capacity to establish contact with partners who can provide the relevant information about changes and innovations in the sector. This impacts positively on assimilation or the capacity to be among the first to recognise technical, regulatory and market-related developments and to evaluate how changes can be applied to their own farm (assimilation). Pig farmers indicate that they acquire their information about developments in the sector mainly from discussions with business partners and participation in meetings organised by the sector (such as the branch organisation LTO). The most important sources of information about new developments in the sector turn out to be other breeders, pig farmers and slaughterhouses from the chain, and from the wider network, consultancies, branch organisation (LTO), knowledge and research institutes (WUR and Sterksel). Table 6.3 gives a short overview of the main implications from the study in Chapter 4.

The conclusions from the study in Chapter 5 are relevant for firms and (non)governmental institutions which collaborate in co-innovation partnerships, and more specifically in public-private partnerships with a long-term pay-off, and sustainability-oriented innovation goals.

Table 6.3 *Short overview of recommendations for knowledge absorption through pig farmers' networking.*

Pig farmers
• Frequent networking within a confined network relates positively to pig farmer innovativeness.
• Innovators focusing on pigs welfare have a more concentrated network than those focusing on planet and people innovations.
• Discussions with business partners and participation in meetings organised by the sector (such as the branch organisation LTO) are the most common knowledge gathering practices among pig farmers which contribute to their external knowledge assimilation capacity or ability to recognise technical, regulatory and market-related developments in the sector.

Structural and relational governance mechanisms can be used to reduce the negative effects of uncertainty related to innovation and heterogeneity related to the network of actors with whom collaboration takes place. Extra-contractual agreements have a specific role in the structuring of the innovation and the collaboration process. The process of making these agreements is highly important because it is at this time in the process that explication of motives and commitment, negotiation and congruence need to take place. Extra-contractual formalisation could be used as a tool to structure the innovation and collaboration process, and explicate and clarify the incentive-based rational commitment.

In order to employ relational governance mechanisms, actors who engage in innovation partnerships or projects need to pay specific attention to selection of their partners. Previous collaboration or familiarity with reputation can entail information about the level of compliance of partners with the agreements made and about the adequateness of their competencies for the innovation project. Also, attitudinal commitment could be present in relationships which have a history. In general, such relational governance mechanisms can be built over time, in the context of a high level of information exchange. However, relational governance mechanisms remain difficult to manage, because they require time and patience to develop and can easily be damaged through self-interested actions. This can have a detrimental effect on the entire

Table 6.4 *Short overview recommendations governance co-innovation partnerships.*

Firms and (non)governmental institutions in co-innovation partnerships
• Extra-contractual formalisation could be used as a tool to structure the co-innovation process, and explicate the incentive-based rational commitment.
• Through their interplay, structural and relational governance mechanisms complement each other during the co-innovation process.
• Relational governance mechanisms require time to develop, but can be damaged very easily.

progress of the project. Table 6.4 gives a short overview of the main implications from the study in Chapter 5.

Summary

Innovation gained increasing importance in the mature agri-food industry to be able to face the fast changes in the technological, economic, environmental and societal fields. For example, environmental problems and ethical issues, such as animal welfare and genetic modification, impose societal demands on the agri-food sector. At the same time, technological developments, such as genetic mapping or DNA marker technology, offer new possibilities for change and innovation. In order to embark upon the technological possibilities and respond to societal and economic changes more effectively, agri-food companies are also increasingly engaging in co-innovation partnerships.

While firm performance is increasingly dependent on the continuous improvement and introduction of new products, innovation is costly, time-consuming and characterized by many uncertainties. For example, only one product concept out of seven becomes a new product winner, half of all new product launches are late to the market and 44% of innovation projects fail to achieve their profit targets (Cooper and Edgett, 2009). Innovation projects impose organizational requirements on companies, such as the organization of the suitable resources and skills, or division of responsibilities and organization of internal knowledge transfer. The uncertainties inherent to innovation processes create (hidden) organization and coordination costs, because developments during the innovation process may require (unanticipated) changes.

In the process of external knowledge acquisition for the purpose of innovation, skills and capabilities are required to assess the importance of specific actors as sources of knowledge, as well as the frequency and extent of contact with these actors. Interaction with and search for knowledge from external sources is a time-consuming activity which requires a specific approach towards its organization to prevent that the costs of interaction and coordination exceed the benefits. In co-innovation partnerships, the involvement of multiple organizations increases the complexity and difficulty of coordination activities (Hobday, 2000). More time and effort is required (Kraut *et al*., 2002; Nardi and Whittaker, 2002) to build a common ground (Clark and Brennan, 1991), maintain awareness of what others are doing (Weisband, 2002), and make rapid adjustments to unexpected developments (Olson and Olson, 2000). Coordination costs can increase as a consequence of misunderstandings (Cramton, 2001), institutional rivalries (Armstrong and Cole, 2002), free riding (Weisband, 2002), or unlawful/unfair appropriation of innovation outcomes.

Adequate management is required to prevent that the costs exceed the benefits of innovation in the context of in-house and co-innovation projects. Therefore:

> *The focus of the present study is on the firm internal and external organizational capabilities and governance mechanisms in innovation partnerships to enhance innovation performance.*

The first part of the present thesis focuses on the management of in-house innovation projects. In the first chapter, the relationship is studied between the innovation characteristics, such as novelty and newness, and the internal functional and integrative capabilities of the firms to improve innovation project performance. As the food and beverages (F&B) industry is typically described as a relatively mature and slow-growing area of business, with rather conservative types of innovations (Costa and Jongen, 2006), in the second chapter it is studied whether different conditions in the F&B and technology-based industries have consequences for the management and success factors of in-house innovation projects.

The second part of the thesis focuses on the exchange of knowledge and collaboration with network actors to innovate and enhance innovation performance. In order to understand how agri-food actors can increase their innovation performance through external knowledge acquisition, in Chapter 4 the organizational capabilities to access, acquire, assimilate, transform and exploit external knowledge is studied among the pig farmers in the Netherlands. The need for increased innovativeness in this sector, and the potential of the network to contribute to its innovativeness, has been the basis for selecting pig farmers as the study object. Chapter 5 focuses on the way in which structural and relational governance mechanisms can be employed most effectively in co-innovation partnerships to exchange knowledge and enhance innovation performance. Public-private co-innovation partnerships are used to study how governance mechanisms can be used to deal with differences, potential opportunistic behaviour and uncertainty of the outcome of the innovation process.

In-house innovation

Research about the success factors for in-house innovation projects is mainly based on empirical studies, such as the SAPHHO study (Rothwell, 1972) and Cooper's pivotal work developing the NewProd assessment tool (e.g. Cooper, 1979, 1987, 1999). Previous studies focused on the collection of a large number of independent variables which affect innovation project performance. These developments in the views on the management of in-house innovation projects remained largely unconnected to theories about firm management, such as the resource-based view. One of the consequences was the predominant focus on the direct relations between a set of independent variables and success or failure of the innovation projects (Cooper, 1999; Lynn *et al*., 1999), without considering the complexity of relations among the different determinants of innovation performance. Within the resource-based view, a strategic perspective to management of innovation was taken, with focus on firm capabilities to acquire, learn and accumulate organizational and intangible assets over time (Teece *et al*., 1997). Despite the possibilities to employ the theoretical ideas from the resource-based view to advance the model of innovation performance determinants (e.g. Cooper, 1979, 1987, 1999), limited research attributed attention to studying the relations between innovation characteristics (innovativeness and newness), functional and integrative firm capabilities, innovation potential and innovation project performance. This is the gap in research that the study in Chapter 2 is addressing. Most of the innovation management

studies were performed in technology intensive fields, where R&D and product development have a central role. Therefore, in Chapter 2, the food processor companies are studied as the chain actor who is involved in product development and who organizes innovation projects in cross-functional teams. In order to improve the understanding of the complexity of direct and indirect relations among the different innovation project performance determinants, the research question addressed is:

Research Question 1 (RQ1): *What are the relationships between innovation characteristics, functional and integrative capabilities, innovation potential and ultimately innovation performance?*

The study in Chapter 2 leads to the conclusion that functional and integrative capabilities of the firm are not directly related to innovation performance, but through a complexity of relations among the innovation potential factors (product, market and project potential). The integrative capability of the firm plays an important role in the combination of different resources and competences which are important for the innovation project. Also, integrative communication enhances the capabilities of the firm to deal with innovation complexity and novelty, and plays an important role in the offsetting of the negative effect of newness on functional capabilities. The integrative, communication capabilities are also specifically important for the potential of innovation, in terms of achieving higher product superiority or product potential.

While the path model in Chapter 2 increases insight about the indirect relations among the determinants of innovation performance, the question remains about the specificities of food and beverages (F&B) innovation projects. The F&B companies differ from technology-based companies, where product generations follow-up each other with a dazzling speed. In contrast, in the F&B industry the end-consumers are considered distrustful towards radically new products and changes in their consumption patterns (Sarkar and Costa, 2008). Such differences in context may impose different requirements on the managerial and organizational firm capacity in case of innovation projects. In order to find out the differences in importance of variables which affect innovation performance in the food-processing and technology-based industries, the question addressed in Chapter 3 is:

Research Question 2 (RQ2): *What are the differences between the food and beverages (F&B) and the technology-based industries as concerns the factors influencing innovation performance?*

The results from Chapter 3 show that newness or unfamiliarity with technologies or processes entailed in the innovation project is among the traps for innovation project success in the F&B companies. The study shows also that specifically functional upstream capabilities (engineering, resources, management, financial skills and resources) are crucial for the distinction between high and low performing innovation projects in the F&B companies (Pandza, 2005; Hayes *et*

al., 1996; Hayes *et al*., 1988; Helfat, 1994; Henderson, 1993; Montgomery and Hariharan, 1991; Stalk *et al*., 1992). These two findings taken together lead to the conclusion that when the project is very new to an F&B company, difficulty is encountered with regards to dealing with the adequateness of upstream functional capabilities. Capabilities to deal with newness can be enlarged through, for example external orientation and internalization of resources and capabilities (Martino and Polinori, 2011). The study in Chapter 3 shows also that market potential increase less strongly the likelihood to successful innovation outcome in F&B than in technology-based innovation projects. Attention to user-oriented innovation (Grunert *et al*., 2008), such as individualized products and short response time (Grunert *et al*., 2008), constitutes promising developments for the F&B industry to improve on the weak factor of market potential.

Chain and network

The developments in innovation management led to emphasis on knowledge as one of the core assets/resources of innovation processes. The capacity of the firm to accumulate knowledge and learn is considered important for its innovative performance and related to the firm's combinative or integrative capabilities. While access, accumulation and building of knowledge are increasingly considered as imperative determinants of competitive advantage of firms, little research attention is attributed to the *organizational capabilities* to assure access, acquisition, assimilation, transformation and exploitation of external knowledge. The study in Chapter 4 embarks on this gap in research by analysing how the *four organizational capabilities of knowledge acquisition, assimilation, transformation, and exploitation build on each other to yield a dynamic capability that influences the firm's ability to create and deploy the knowledge necessary to build other organizational capabilities (e.g. marketing, distribution, and production)* (Zahra and George, 2002). This is studied in the context of pig farmers, because the ever-increasing intensification in pig farming has sharpened the attention of societal and consumer organizations to sustainability-oriented innovation where the farmers have to make use of their network partners to increase their innovativeness. The study in Chapter 4 reverts to the definition of absorptive capacity as '*a set of organizational routines and processes,* and studies the *multidirectional and fluid path* [among the different dimensions of absorptive capacity], *rather than a patterned* [sequential] *trajectory of knowledge acquisition* [to] *exploitation*' (Zahra and George, 2002, p. 198). The research question addressed in Chapter 4 is:

Research Question 3 (RQ3): *What is the relationship between networking behaviour and absorption of external knowledge, and innovation and business performance?*

The study in Chapter 4 establishes support for the dynamic nature of absorptive capacity by showing that the capacity to *transform* knowledge (recognize opportunities and consequences of new external knowledge) can enhance the (*acquisition*) capacity to allocate the network actors who can provide knowledge about innovations in the sector. It also points to the centrality

of assimilation capacity (the ability to recognize relevant changes and possibilities) to the absorptive capacity of the firm. At the same time, it addresses the potential of *organizational capabilities* to access knowledge which is neglected in studies with a social network perspective. The findings show that external knowledge access through the organization of networking (in terms of networking frequency in a diverse but confined network range) affects innovativeness in a positive way directly, but also indirectly through acquisition and assimilation capacity.

Next to ideas about strategic orientation towards knowledge acquisition, the knowledge intensive economy caused also fundamental changes in the firm organization and its governance. The increasing disaggregation of firms through outsourcing and out-licensing and the predominance of knowledge and human capital (over physical capital) for value creation are changing the boundaries of the firm (Foss, 2007). Innovation and the exchange of knowledge take place in new types of organizational constellations, such as networks and temporary projects or alliances. In terms of management of these human capital and knowledge-intensive types of activities, the emphasis became mainly on social norms and pressures as the modes of organizational control (e.g. Child and McGrath, 2001), with limited attention to structural governance and assessment of the efficient form of governance. In order to address this gap in research, the study in Chapter 5 focused specifically on the two traits, innovation uncertainty and network heterogeneity, which can increase coordination costs. While innovation uncertainty complicates the planning and organizing of the innovation process, network heterogeneity increases the information-processing requirements and the need for additional effort and coordination to align different interest and views. As both of the conditions are present at the same time, and evolve during the co-innovation process, in Chapter 5 it is explored how the interplay between structural and relational governance mechanisms can contribute to minimization of these organizational challenges and maximization of benefits of co-innovation. Accordingly, the study in Chapter 5 addresses the question:

Research Question 4 (RQ4): *How can the interplay between structural and relational governance mechanisms tackle the organizational challenges entailed in innovation uncertainty and network heterogeneity in co-innovation partnerships?*

The conclusions from the study in Chapter 5 point mainly to the intertwined character between the structural and relational governance mechanisms to minimize challenges and maximize benefits of co-innovation. Extra-contractual formalisation (Grandori and Furlotti, 2010) of aims and planning constitute the basis for the achievement of commonalities, explication of motives and commitment, and solving of coordination problems (Omta and Van Rossum, 1999). Convergence of interests is specifically important to assure that partners can recognise their interests in the aims of the partnership and acquire incentive-based rational commitment. Compliance trust and attitudinal commitment can play a role in the implementation of the agreements. However, these relational governance mechanisms require rational commitment to develop, and are complementary to this structural, self-

interest-based incentive. Competence trust requires insight about the complementarities of individual competencies. This insight can help to envision the possibilities for the innovation outcome, which means that competence trust can be a pre-condition for rational commitment to develop (further).

Each of the four studies has a specific theoretical contribution. These can be listed as follows:

- Through employment of the resource-based view on functional and integrative capabilities, insight into the indirect and complex relations among the determinants of innovation performance is increased, improving the existing model of direct relations between a large number of independent variables and innovation project performance (Cooper, 1979, 1987, 1999).
- The studying of determinants of innovation project performance in a mature industry such as the agri-food, demonstrated that there are differences in the importance of factors for successful technology-based and F&B innovation projects. The comparative approach to the analysis in this study contributes specifically to the distinction of stronger and weaker factors in F&B innovation projects.
- The study addresses the lack of research about the *organizational capabilities* entailed in the networking behaviour of firms. It also establishes support for the dynamic nature of absorptive capacity by showing that the capacity to *transform* knowledge can enhance the (*acquisition*) capacity to allocate the network actors who can provide knowledge about innovations in the sector.
- Exploring the relations between organizational challenges, related to innovation uncertainty and network heterogeneity, and structural and relational governance mechanisms, it is concluded that the intertwined character of these mechanisms optimizes inter-firm innovation outcomes. This tackles the fallacy in existing research to employ also structural governance mechanisms in inter-firm knowledge exchange conditions and increase the efficiency of organization of co-innovation partnerships.

The combined contribution and conclusion is that next to the internal functional and integrative capabilities (Pandza, 2005; Grant, 1991; Henderson and Cockburn, 1994), also external integrative capabilities are important for innovation performance. Internal capabilities include functional upstream and downstream capabilities, and the distinctively important integrative capabilities, such as (team) communication. External integrative capabilities entail external knowledge access through frequent networking within a confined network, and knowledge acquisition through identification of most important sources of knowledge and participation in sector meetings. This can increase the assimilation capacity and with this the level of innovativeness of the firm.

Next to internal and external integration of knowledge, innovation performance is also enhanced through the ability to reap the benefits from cross-company innovation. The study shows that co-innovation benefits can be maximised through employment of the intertwined structural and relational governance mechanisms. Especially because innovation

and collaboration are dynamic processes, the complementing character of extra-contractual formalisation, rational and attitudinal commitment and compliance and competence trust is needed throughout the process to assure knowledge mobility and network stability (Dhanaraj and Parkhe, 2006).

Samenvatting

Innovatie speelt een steeds belangrijkere rol in de agro-food industrie om op de snelle technologische, economische, ecologische en maatschappelijke veranderingen in te kunnen spelen. Milieuproblemen en ethische kwesties, zoals dierenwelzijn en genetische modificatie, stellen maatschappelijke eisen aan de agro-food bedrijven. Tegelijkertijd bieden technologische ontwikkelingen, zoals genetic mapping of DNA-marker-technologie, nieuwe mogelijkheden voor verandering en innovatie. Om in te kunnen spelen op de technologische mogelijkheden en effectiever te reageren op maatschappelijke en economische veranderingen zijn agro-food bedrijven ook steeds meer betrokken bij co-innovatie partnerschappen.

Prestaties van bedrijven worden steeds afhankelijker van voortdurende verbetering en nieuw product introductie. Tegelijkertijd is innovatie duur, tijdrovend en wordt het gekenmerkt door vele onzekerheden. Bijvoorbeeld, slechts een van de zeven product concepten resulteert in een nieuw prdouct, de helft van de productlanceringen bereikt te laat de markt en 44% van innovatieprojecten lukt het niet om aan de winstdoelstellingen te voldoen (Cooper en Edgett, 2009). Innovatieprojecten stellen organisatorische en coördinatie eisen, zoals de organisatie van geschikte middelen en vaardigheden, verdeling van verantwoordelijkheden en de organisatie van de interne kennisoverdracht. De onzekerheden die inherent zijn aan innovatieprocessen kunnen (verborgen) organisatorische en coördinatie kosten creëren, omdat de ontwikkelingen tijdens het innovatieproces veranderingen en vertraging kunnen veroorzaken.

Voor externe kennisverwerving ten behoeve van innovatie speelt het vermogen van bedrijven een grote rol in het beoordelen van het belang van specifieke actoren als kennisbronnen, en de frequentie en omvang van contact met deze actoren. Interactie en het zoeken naar kennis uit externe bronnen is een tijdrovende bezigheid die een specifieke benadering vergt om te voorkomen dat de kosten van interactie en coördinatie de voordelen overstijgen. In co-innovatie kan de pluraliteit van keten en netwerk actoren de coördinatie kosten verhogen door bijvoorbeeld ongelijke organisatorische structuren of organisatiecultuurverschillen. Wanneer er meerdere organisaties betrokken zijn bij een project, neemt de complexiteit en moeilijkheidsgraad van de coördinatie-activiteiten toe (Hobday, 2000). Meer tijd en inspanning is vereist (Kraut *et al*., 2002;. Nardi en Whittaker, 2002) om gemeenschappelijkheden op te bouwen (Clark en Brennan, 1991), om ervoor te zorgen dat iedereen bewust blijft van de activiteiten van de projectpartners (Weisband, 2002) en snelle aanpassingen uit te voeren op onverwachte ontwikkelingen (Olson en Olson, 2000). Coördinatiekosten kunnen stijgen als gevolg van misverstanden (Cramton, 2001), institutionele rivaliteit (Armstrong en Cole, 2002), free-riding (Weisband, 2002), of onrechtmatige toe-eigening van innovatieresultaten. Adequaat management is noodzakelijk om te voorkomen dat de kosten de voordelen van innovatie overstijgen, in het kader van in-house en co-innovatie projecten. Om deze reden focust deze studie op:

> *bedrijf interne en externe organisatorische bekwaamheden en governance-mechanismen in co-innovatie partnerschappen om innovatieprestatie te verbeteren.*

Het eerste deel van het proefschrift richt zich op het management van in-house innovatieprojecten. In het eerste hoofdstuk wordt de relatie bestudeerd tussen innovatiekenmerken, zoals nieuwheid van het project voor de markt en voor het bedrijf, en de interne functionele en integratieve capaciteiten van het bedrijf om innovatieprestatie te verbeteren. Aangezien de agro-food sector verschilt van technologie-intensieve industriën, wordt in het tweede hoofdstuk onderzocht of de verschillende omstandigheden in de levensmiddelen en technologie-intensievere bedrijven gevolgen hebben voor de management en de succesfactoren van in-house innovatieprojecten.

Het tweede deel van het proefschrift richt zich op de uitwisseling van kennis en samenwerking met externe actoren om te innoveren en innovatieprestatie te verbeteren. Om te begrijpen hoe de agro-food actoren hun innovatieprestaties kunnen verhogen door middel van externe kennisverwerving, worden in Hoofdstuk 4 de organisatorische capaciteiten van de Nederlandse varkenshouders bestudeerd om toegang te krijgen tot externe kennis, deze te verwerken, te transformeren en te exploiteren. De behoefte aan meer innovatie, en het potentieel van het netwerk om bij te dragen aan innovatie in deze sector, vormt de basis voor het selecteren van varkenshouders als studieobject. Hoofdstuk 5 richt zich op de wijze waarop structurele en relationele governance-mechanismen het meest effectief ingezet kunnen worden in co-innovatie om kennis uit te wisselen en innovatieprestatie te verbeteren. Er wordt onderzocht hoe in publiek-private co-innovatieprojecten governance mechanismen gebruikt kunnen worden om de verschillen tussen partners, potentieel opportunistisch gedrag en de onzekerheden over de uitkomsten van het innovatieproces te managen.

In-house innovatie

Onderzoek naar de succesfactoren van in-house innovatieprojecten is voornamelijk gebaseerd op empirische studies, zoals de SAPHHO studie (Rothwell, 1972) en het toonaangevende werk van Cooper omtrent de ontwikkeling van de NewProd assessment tool (bijvoorbeeld Cooper, 1979, 1987, 1999). Voorgaande studies zijn geresulteerd in een breed scala aan onafhankelijke variabelen die innovatieprojectprestatie beïnvloeden. De ontwikkelingen op het gebied van management van in-house innovatieprojecten bleef grotendeels los staan van theorieën op het gebied van bedrijfmanmagement, zoals de resource-based view. Een van de gevolgen was de overheersende focus op de directe relatie tussen een set van onafhankelijke variabelen en het succes of falen van innovatieprojecten (Cooper, 1999;. Lynn *et al*., 1999), zonder rekening te houden met de complexiteit van relaties tussen de verschillende determinanten van innovatieprestatie. Binnen de resource-based view, werd een strategisch perspectief genomen ten aanzien van innovatiemanageent, met nadruk op bedrijfscapaciteiten om organisatorische-en immateriële middelen te verwerven en te leren (Teece *et al*., 1997). Ondanks de mogelijkheden om de theoretische ideeën van de resource-based view te gebruiken om het model van innovatieprestatie determinanten te verbeteren (bijvoorbeeld Cooper, 1979, 1987, 1999) is er weinig onderzoek dat hiertoe een poging heeft gedaan. De relaties tussen innovatiekenmerken (innovativiteit en nieuwheid), functionele en integratieve

bedrijfscapaciteiten, innovatiepotentieel en innovatieprojectprestatie bleef onderbelicht. Dit is de kloof in het onderzoek dat de studie in Hoofdstuk 2 aanpakt. Het merendeel van de innovatiemanagementstudies werden uitgevoerd in technologie-intensieve gebieden, waar R & D en productontwikkeling een centrale rol spelen. Om deze reden wordt in Hoofdstuk 2 specifiek gekeken naar de verwerkingsbedrijven in de levensmiddelenindustrie als de ketenspeler die productontwikkeling onderneemt en innovatieprojecten in cross-functionele teams organiseert. Met het doel om de complexiteit van de directe en indirecte relaties tussen de verschillende determinanten van innovatieprojectprestatie beter te begrijpen, wordt de volgende onderzoeksvraag gesteld in Hoofdstuk 2:

Onderzoeksvraag 1: *Wat is de relatie tussen innovatiekenmerken, functionele en integratieve bedrijfscapaciteiten, innovatiepotentieel en innovatieprojectprestatie?*

De studie in Hoofdstuk 2 leidt tot de conclusie dat functionele en integratieve bedrijfscapaciteiten geen direct, maar een indirect verband houden met innovatieprojectprestatie, door middel van een complexiteit aan relaties met innovatiepotentieel factoren (product-, markt-en project potentieel). Het integrerend vermogen van het bedrijf speelt een belangrijke rol in de combinatie van verschillende middelen en competenties die belangrijk zijn voor het innovatieproject. Daarnaast verbetert integratieve communicatie de capaciteiten van het bedrijf om met innovatiecomplexiteit en -nieuwheid om te gaan en speelt het een belangrijke rol in de compensatie van het negatieve effect van nieuwheid op de functionele bedrijfscapaciteiten. Tevens zijn de integratieve communicatiecapaciteiten van belang om hogere productsuperioriteit of productpotentieel te bereiken.

Terwijl het padmodel in Hoofdstuk 2 het inzicht over de indirecte relaties tussen de determinanten van innovatieprestatie verbetert, blijft de vraag bestaan wat de specifieke kenmerken zijn van innovatieprojecten in de levensmiddelenindustrie. De levensmiddelen verwerkende bedrijven verschillen van technologie-intensieve bedrijven, waar productgeneraties elkaar met een duizelingwekkende snelheid opvolgen. In tegenstelling tot het laatstgenoemde, staan de consumenten van levensmiddelen juist vrij wantrouwend tegenover radicaal nieuwe producten en veranderingen in hun voeding en consumptiepatronen (Sarkar en Costa, 2008). Dergelijke verschillen in context kunnen verschillende eisen stellen aan het management en organisatie van innovatieprojecten. Om te weten te komen of er verschil is in belangrijkheid van de variabelen die innovatieprojectprestatie in de voedselverwerkende en technologie-intensieve bedrijven beïnvloeden, wordt de vraag gesteld in Hoofdstuk 3:

Onderzoeksvraag 2: *Wat zijn de verschillen in factoren die innovatieprojectprestatie beïnvloeden in de levensmiddelen en technologie-intensieve bedrijven?*

De resultaten in Hoofdstuk 3 laten zien dat nieuwheid of onbekendheid met technologiën of processen, die het innovatieproject kenmerken, een van de valkuilen is voor innovatieproject succes binnen levensmiddelenbedrijven. De studie toont ook aan dat met name de functionele

upstream-bedrijfscapaciteiten (zoals engineering, management, financiële vaardigheden en middelen) cruciaal zijn voor het onderscheid tussen hoge en lage innovatieprojectprestatie binnen levensmiddelen producerende bedrijven (Pandza, 2005; Hayes *et al*., 1996; Hayes *et al*., 1988; Helfat, 1994; Henderson, 1993; Montgomery en Hariharan, 1991; Stalk *et al*., 1992). Deze twee bevindingen samen leiden tot de conclusie dat in het geval van projecten die nieuw zijn voor de levensmiddelenproducent, moeite wordt ondervonden om de juiste upstream-functionele capaciteiten te waarborgen. Externe oriëntatie en het naar binnen halen van additionele middelen en capaciteiten kan de kracht van levensmiddelenproduceten vergroten om met nieuwheid van projecten om te gaan (Martino en Polinori, 2011). De studie in Hoofdstuk 3 laat ook zien dat marktpotentieel minder sterk de kans op succesvolle innovatieprojecten verhoogt in het geval van levensmiddelenproducenten dan in het geval van technologie-intensieve bedrijven. Aandacht voor de eindgebruiker (Grunert *et al*., 2008), zoals geïndividualiseerde producten en korte reactietijd (Grunert *et al*., 2008), is onderdeel van veelbelovende ontwikkelingen binnen de levensmiddelenindustrieom op dit zwakke punt te verbeteren.

Keten en netwerk

De ontwikkelingen in innovatiemanagement leidden tot nadruk op kennis als een van de belangrijkste middelen voor innovatie. De integratieve bedrijfscapaciteit om kennis te vergaren en te leren wordt beschouwd als een belangrijk aspect voor bedrijfsinnovatieprestatie. Terwijl de toegang, verzameling en opbouw van kennis steeds belangrijker wordt geacht is er relatief weinig onderzoek naar de organisatorische capaciteiten om toegang, acquisitie, assimilatie, transformatie en exploitatie van externe kennis te waarborgen. De studie in Hoofdstuk 4 draagt bij aan deze leemte in onderzoek door juist nadruk te leggen op de organisatorische capaciteiten om externe kennis te verwerven, assimileren, transformeren en te exploiteren en vast te stellen hoe deze organisatorische capaciteiten op elkaar bouwen om dynamiek binnen het bedrijf te creëren ter bevordering van andere organisatorische capaciteiten (bv., marketing, distributie en productie) (Zahra en George, 2002). Dit wordt onderzocht in het kader van varkenshouders, waarvan het netwerk potentieel biedt om bij te dragen aan duurzame innovatie ter tegenmoetkoming van de toenemende kritiek van maatschappelijke en consumentenorganisaties op de intensieve bedrijfsvoering. De studie in Hoofdstuk 4 grijpt terug naar de definitie van absorptievermogen als een reeks van organisatorische routines en processen, en kijkt naar de multidirectionaliteit tussen de verschillende dimensies van absorptievermogen, in plaats van het [sequentiele) traject van verwerving [naar] uitbuiting van externe kennis (Zahra en George, 2002, p. 198). De onderzoeksvraag in Hoofdstuk 4 luidt:

Onderzoeksvraag 3: *Wat is de relatie tussen het netwerk gedrag, absorptie van externe kennis en innovatie- en bedrijfsprestatie?*

De studie in Hoofdstuk 4 vindt ondersteuning voor het dynamische karakter van absorptievermogen door middel van het resultaat dat de capaciteit om kennis te transformeren

(herkenning van kansen en gevolgen van nieuwe kennis) de (acquisitie) capaciteit kan bevorderen om de juiste netwerk contacten te identificeren die kennis kunnen leveren over de innovaties in de sector. De resultaten wijzen ook op de centrale rol van assimilatiecapaciteit (het vermogen om relevante veranderingen en mogelijkheden te herkennen) binnen het absorptievermogen van bedrijven. Tegelijkertijd wordt het door sociale netwerk studies verwaarloosde potentieel van *organisatorische capaciteiten* om toegang tot externe kennis te verzekeren aangekaart. De bevindingen tonen aan dat toegang tot externe kennis door het eigen netwerkgedrag op de juiste wijze te organiseren een positief direct en indirect effect heeft op de innovativiteit van het bedrijf.

Naast de ideeën over strategische oriëntatie ten opzichte van kennisverwerving, heeft de kennisintensieve economie ook fundamentele veranderingen veroorzaakt in de bedrijfsorganisatie en bestuur. De toenemende disaggregatie van bedrijven door middel van outsourcing, verlenen van licenties en het overwicht van kennis en menselijk kapitaal (boven fysiek kapitaal) voor waardecreatie veranderen de grenzen van ondernemingen (Foss, 2007). Innovatie en de uitwisseling van kennis vindt plaats in nieuwe organisatievormen, zoals netwerken en tijdelijke allianties. Om het menselijk kapitaal en kennis-intensieve activiteiten te managen is met name nadruk gelegd op de kracht van sociale normen en druk als organisationele controlemiddelen (bijv. Child en McGrath, 2001) met beperkte aandacht voor structurele governance en efficiënt management. Om deze kloof in onderzoek aan te pakken, is de studie in Hoofdstuk 5 specifiek gericht op de organisatorische uitdaging van kennismanagement veroorzaakt door innovatieonzekerheid en netwerkheterogeniteit. Innovatieonzekerheid geeft de moeilijkheidsgraad van het plannen en organiseren van het innovatieproces weer, terwijl netwerkheterogeniteit extra inspanning en coördinatie vergt om in de nodige informatieverwerking te voorzien en de verschillende belangen en visies op een lijn te brengen. Aangezien beide omstandigheden tegelijkertijd co-innovatie partnerschappen kenmerken en zich ontwikkelen tijdens het co-innovatie proces, wordt in Hoofdstuk 5 onderzocht hoe de wisselwerking tussen structurele en relationele governance-mechanismen kan bijdragen aan het minimaliseren van de organisatorische uitdagingen en het maximaliseren van de voordelen van co-innovatie. De studie in Hoofdstuk 5 richt zich op de vraag:

Onderzoeksvraag 4: *Hoe kan de wisselwerking tussen structurele en relationele governance mechenismen de organisationele uitdagingen inherent aan innovatieonzekerheid en netwerkheterogeneiteit in co-innovatie partnerschappen aanpakken?*

De conclusies van de studie in Hoofdstuk 5 wijzen met name op het verweven karakter tussen structurele en relationele governance-mechanismen om organisationele uitdagingen te minimaliseren en de voordelen van co-innovatie te maximaliseren. Extra-contractuele formalisering (Grandori en Furlotti, 2010) van de doelstellingen en planning vormen de basis voor het stellen van gemeenschappelijke doelen, expliciet maken van motieven en verbintenis tot het project, alsook het oplossen van coördinatieproblemen (Omta en Van Rossum, 1999).

Convergentie van belangen zorgt er met name voor dat partners hun belangen kunnen herkennen in de doelstellingen van het partnerschap om het zelf-regulerende mechanisme van stimulerende rationele verbintenis te laten werken. Vetrouwen in de naleving van gemaakte afspraken en attitude commitment kunnen een rol spelen bij de uitvoering van de gemaakte afspraken. Echter, voor deze relationele governance mechanismen te ontwikkelen is rationele verbintenis nodig. Dit maakt de laatstgenoemde relationale mechanismen complementair aan de structurele, eigenbelang-gebaseerde prikkel (rationele verbintenis). Vetrouwen in de competentie van partners vereist inzicht in de complementariteit van de individuele competenties. Dit kan helpen om de potentiële innovatieresultaten inzichtelijk te maken. Dit betekent dat vertrouwen in competenties een voorwaarde kan zijn voor de (verdere) ontwikkeling van rationele verbintenis.

Elk van de vier deel-onderzoeken heeft een specifieke theoretische bijdrage. Deze kunnen als volgt worden opgesomd:

- Door gebruik te maken van de resource-based view en de functionele en integratieve bedrijfscapaciteiten in Hoofdstuk 2, is het inzicht in de indirecte en complexe relaties tussen de determinanten van innovatieprojectprestatie vergroot. Hiermee is het model van directe relaties tussen een groot aantal onafhankelijke variabelen en innovatieprojectprestatie een stap verder gebracht (Cooper, 1979, 1987, 1999).
- De studie in Hoofdstuk 3 heeft aangetoond dat er verschillen zijn in de belangrijkheid van innovatieprojectprestatie determinanten tussen innovatieprojecten van levensmiddelenproducenten en technologie-intensieve bedrijven. De vergelijkende analyseaanpak draagt met name bij aan verduidelijking van de sterke en zwakke factoren voor innovatieprojecten van levensmiddelenproducenten.
- De studie in Hoofdstuk 4 heeft het gebrek aan aandacht voor de organisatorische bedrijfscapaciteiten om netwerkgedrag in te richten aangepakt door het bedrijfsorganisatievermogen te bestuderen om toegang te krijgen tot externe kennis door de juiste netwerkfrequentie en diversiteit binnen het netwerk. De resultaten ondersteunen ook het vermeende dynamische karakter van absorptievermogen door te laten zien dat de capaciteit om kennis te transformeren een positief effect kan hebben op de acquisitie capaciteit (de capaciteit die bedrijven in staat stelt om de juiste netwerk actoren te identificeren om kennis over innovaties in de sector te verkrijgen). Er is dus een terugkoppelend effect werkzaam tussen de absorptievermogen capaciteiten.
- Door de relaties te verkennen tussen organisatorische uitdagingen, gecreëerd door innovatieonzekerheid en netwerkheterogeniteit, en structurele en relationele governance-mechanismen wordt in Hoofdstuk 5 geconcludeerd dat het verweven karakter van deze twee soorten mechanismen juist co-innoverende bedrijven in staat stelt om de innovatieresultaten te optimaliseren. Dit pakt de misvatting in bestaand onderzoek aan dat structurele governance-mechanismen minder geschikt zijn voor onzekere omstandigheden zoals innovatie. De studie geeft weer dat in de context van kennisuitwisseling tussen bedrijven de co-innovatie organisatie juist efficiënter ingericht kan worden door toepassing van ook de structurele, in plaats van enkel de relationele, governance mechanismen.

De gezamenlijke bijdrage en conclusie is dat naast de interne functionele en integratieve bedrijfscapaciteiten (Pandza, 2005; Grant, 1991; Henderson en Cockburn, 1994), ook extern gerichte integratieve capaciteiten van bedrijven een belangrijke rol spelen in de bepaling van innovatieprestatie. De belangrijke interne capaciteiten zijn met name de functionele upstream- en downstream-middelen en bekwaamheden en de van onderscheidend belang integratieve capaciteiten, zoals (team) communicatie. Extern-gerichte integratieve capaciteiten stellen de bedrijven in staat om toegang tot externe kennis te organiseren door frequent te netwerken met een aantal essentiële actoren, identificatie van de belangrijkste bronnen van kennis over innovatie en deelname aan sector vergaderingen. Door middel van deze organisatie van toegang tot externe kennis kunnen bedrijven hun capaciteit om exterene kennis te assimileren, en met dit de innovativiteit van het bedrijf vergroten.

Naast de capaciteit om interne en externe kennis te integreren kan de innovatieprestatie ook verbeterd worden door de voordelen van co-innovatie te plukken. De studie toont aan dat co-innovatie voordelen kunnen worden gemaximaliseerd door de met elkaar verweven structurele en relationele governance mechanismen aan te wenden. Vooral omdat innovatie en samenwerking dynamische processen zijn, is het complementaire karakter van de extra-contractuele formalisering, rationele en attitudinale verbintenis en vertrouwen van belang om tijdens het gehele proces kennis mobiliteit en stabiliteit van het netwerk (Dhanaraj en Parkhe, 2006) te verzekeren.

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Appendices

Appendix 1

Table A1.2 *Structural model path coefficients and t-values.*

	Path coefficient	t-value
Communication R^2 =0.13		
Novelty	0.22	2.80
Newness to the firm	-0.15	1.72
Upstream resources R^2 =0.36		
Newness to the firm	-0.26	4.25
Communication	0.51	9.34
Novelty	0.02	0.23
Downstream resources R^2 =0.17		
Newness to the firm	-0.19	2.79
Communication	0.30	4.58
Innovation process quality R^2 =0.19		
Market potential	0.34	4.09
Novelty	-0.11	1.13
Newness to the firm	-0.14	1.61
Communication	0.07	0.81
Product potential R^2 =0.43		
Upstream resources	0.04	0.45
Downstream resources	-0.03	0.43
Communication	0.44	6.86
Novelty	0.34	4.61
Market potential R^2 =0.39		
Product potential	0.58	9.66
Market competition	0.17	2.83
Downstream resources	-0.03	0.45
Project potential R^2 =0.46		
Market potential	0.47	6.65
Innovation process quality	0.29	4.15
Innovation performance R^2 =0.16		
Project potential	0.21	2.45
Innovation process quality	0.12	1.48

Appendix 2

Function	Age
Education (*Circle one option)*	Secondary school / Mid-level Vocational Training / School of Applied Sciences / University
Number of pigs	Number of sows
Number of employees	Number of employees involved in innovation
Our company has existed for	□ 0 to 5 years □ 5 tot10 years □ 10 to 15 years □ 15 to 20 years □ 20 years or longer
If you would retire in 5 years, is there a successor to take over your company?	□ No □ Yes, my son/a buyer

Turnover in the year 2010 was (*Please choose one of the options)*

□ Less than 300.000	□ 1 - 2 mil.
□ 400,000 - 600,000	□ 2 - 4 mil.
□ 600,000 - 800,000	□ 4 - 8 mil.
□ 800,000 - 1 mil.	□ 8 mil. or more

Networking access to external knowledge

How often do you have contact with each (category of) organisation(s) for your access to external knowledge and information? (*Please choose the option that best approaches the actual situation. 1= never 2= less than annually 3= annually 4=biannually 5= bimonthly 6= monthly 7 = weekly)*

Company/organisation	**Certifiers**	**Knowledge institutes**
Feed companies	PVV-CBD/VERIN[1] (IKB Pigs)	Wageningen University
Feed systems companies	The Green lobbyist (DGB) (IKB	Van Hall Larenstein
Veterinaries	Netherlands Pigs)	HAS Den Bosch
Pig/sow farmers	SKAL (EKO)	Pigs Innovation Centre Sterksel
Abattoirs/slaughterhouses	Foundation Milieukeur	
Meat processors		
Transport companies	**Government institutions**	**Animal welfare and environment**
Supermarkets		
Butcheries	Ministry of economic Affairs,	
Banks	Agriculture and Innovation	Animal protection
Consultancies	Agentschap.NL	Health services for Animals (GD)
Accountants		Environment defence (*Milieudefensie*)
	Branch organisations	Foundation *Wakker Dier*
		Party for Animals
	Agriculture organisation	Foundation for Nature and
	Netherlands (LTO)	Environment (SNM)
	Dutch Union for pig farmers	
	Product Boards Livestock and	
	Meat (PVV)	

[1]Verification Institute Quality systems

Please indicate to what extent you make use of external sources, knowledge and information for the following issues: (*1 = very poorly and 7 = intensively)*

- Animal welfare
- Veterinary issues
- Marketing
- Regulation
- Environmental issues
- Subsidies
- Collaboration

Please indicate to what extent you agree with the following statements: (*1 = completely disagree and 7 = completely agree)*

Acquisition capacity

- We collect information about developments in the sector through discussions with business partners from the sector.
- Our farm participates at least twice a year in seminars and sector organised conferences to upgrade their expertise and knowledge.
- We devote a lot of time to the establishment of contact with parties which can provide us with knowledge and information about innovations in the sector.
- We have sufficient skills to establish contact with parties which can provide us with knowledge and information about innovations in the sector.

Assimilation capacity

- Our farm is always among the first to recognise shifts in technical possibilities.
- Our farm is always among the first to recognise shifts in regulation.
- Our farm is always among the first to recognise shifts in market competition.
- Our farm is very skilful in detecting new possibilities to serve new customers.
- Our farm devotes a lot of time to deliberating with advisors in order to recognise changes in the market early.
- Our farm has sufficient skills to deliberate with advisors about the way in which the changes in the market can be used to make changes to the business in our farm.

Transformation capacity

- We record and store newly acquired knowledge for future reference.
- Our farm recognises quickly the usefulness of new external knowledge to our existing knowledge.
- We discuss monthly with external advisors about the way in which trends in the market could be used to improve our business.
- We devote a lot of time to translation of external information into adaptations to our business.
- We have sufficient skills to translate external information into adaptations to our business.

Exploitation capacity

- We translate external information directly into new business applications.
- Application of external information to our business contributes to our profitability.
- We have sufficient skills to convert external information into profitability.

Profitability

(*1=much lower and 7=much higher*)

- How do you estimate your profitability compared to your competitors?
- Compared to our most important competitors our turnover is
- Compared to our most important competitors our growth percentage is

Innovativeness

We are investing in: (*1 = not at all; 4 = in a part of the company; 7 = in the entire company*)

□ Balance farrowing pens
□ Fresh noses farrowing pens
□ Watras farrowing pens
□ Direct separation of urine and manure
□ Biomass plants
□ Wind energy
□ Solar collectors/Solar panels
□ (Animal) warmth recovery / exchanger
□ Daylight - more than 2% stable surface
□ Additional space per animal
□ Exit to open air
□ Rooting place
□ Micro filtering of air
□ Conditioned air inlet
□ Individual registration feed and water intake
□ LED light
□ CCM facility
□ Mechanical broadcast
□ Spraying robot
□ Mixing room sows
□ Mist cooling
□ Pad-cooling
□ Shoulder cooling
□ Rubbing board

Appendix 3

Table A3.1 *Operational definitions.*

Concept	Operational definition
Network heterogeneity	The number of different types of organisations per network is used as a measure of heterogeneity (Monge *et al*., 1998). The types of organisations are classified according to categories of International Standard Industrial Classification (ISIC) list, with economic activities in a hierarchical, four-level structure of mutually exclusive categories. Low network heterogeneity = 1 to 8 types of organisations; high network heterogeneity = 9 types of organisations or more.
Innovation uncertainty 7-point Likert scale	The partners knew at the start of the collaboration which activities they specifically needed to undertake to achieve the goals of the innovation process. [re-scored] 1 = very low 7 = very high Certainty is high that there will be a market for the outcome/ innovation. (Lippman and Rumelt, 1982; Sapienza and Gupta, 1994; Zaltman, Duncan and Holbeck, 1973) [re-scored] 1 = very low 7 = very high
Structural governance	
Formalisation (extra)contractual inventory of agreements summation of number of agreements makes the level of formalisation	Extra-contractual agreements are settled internally by the network partners in case of conflict, while contractual agreements enable conflict resolution by means of judicial rule and legal proceedings (Grandori and Furlotti, 2010). Gulati's (2007) classification is used: (1) incentive systems: aims, investments, property rights (including IPR) (2) monitoring behaviour: progress assessment criteria, sanctions for non-compliance (3) dispute resolution procedures: conflict resolution procedures (internal dispute resolution/ arbitration), termination of cooperation/formal or strict criteria for entrance of new members (4) knowledge protection: confidentiality agreements (5) standard operating procedures: task division, time planning, extension clauses, (6) command structure and authority systems: decision-making (Gulati, 2007; Garndori and Furlotti, 2010, Hagedoorn and Hesen, 2007; Vlaar, Bosch and Van den Volberda, 2007; Perillo, 1998; Eisenberg, 2000; Feinman, 1990 ; Nassar, 1995; Williamson, 1985; Speidel, 2000).
Interviews	Per agreement it has been asked about the importance, satisfaction and actual appliance of the agreement.

Table A3.1 *Continued.*

Concept	Operational definition
Structural governance (continued)	
Rational commitment 7-point Likert scale Semi-structured interviews; Documents	Involves a potential for rewards, such as expected (short- or long-term) return on investments (Cullen *et al*., 2000). Willing to make additional investments in the innovation network, if needed. (Cullen *et al*., 2000). General and individual rational commitment indicators: time investment, support from management, origin of ideas (entrepreneurs, researchers, governmental or societal organisations), common ownership of aims; time and effort put into coordination by network manager.
Relational governance	
Attitudinal commitment 7-point Likert scale Semi-structured interviews	We would drop the current partners if we came across parties with better innovation ideas. There is a strong sense of loyalty among the partners. Continuation of cooperation with the current partners is more or less self-evident. (Ring and Van de Ven 1992; Muthusamy and White, 2005).
Trust Semi-structured interviews 7-point Likert scale Competence Compliance Previous cooperation	Trust is defined as confidence in or positive expectations about partners' behaviour, and confidence in their fairness or goodwill (Ring and Van de Ven, 1992). Indicators: previous cooperation, belief in positive intentions of the partners, concern about the interests of the partner(s); willingness to accept unmet expectations or inequalities to help his/her partner(s); the extent to which partner(s) keep promises and show consistency in their actions; the extent to which there is congruence in values and principles among the partners (Muthusamy and White, 2005; Claro, 2004; Heide and John, 1992). The key partners have specialised capabilities that add value to the innovation. The key partners always fulfil their promises. Proportion of partners who have cooperated previously (Heide and John, 1992; Klein Woolthuis, 1999; Claro, 2004). The percentage of partners who have cooperated previously is converted to a 1 to 7 measure, where 1 represents 14% and less and 7 represents 85% and more of partners cooperating previously.

Table A3.2 *Examples of low and high heterogeneity networks.*

Example heterogeneity of a small size network - 4 ISIC categories:
(1)Agriculture, forestry and fishing, growing of non-perennial crops; (2) Public administration and defence; compulsory social security, regulation of the activities of providing health care, education, cultural services and other social services, excluding social security; (3) Professional, scientific and technical activities, research and experimental development on natural sciences and engineering; (4) Professional, scientific and technical activities, management consultancy activities.
Example heterogeneity of a large size network - 18 ISIC categories:
(1) Professional, scientific and technical activities, management consultancy activities; (2) Education; (3) Public administration and defence; compulsory social security; general public administration activities; (4) Professional, scientific and technical activities, Research and experimental development on natural sciences and engineering; (5) Professional, scientific and technical activities, research and experimental development on social sciences and humanities; (6) Other service activities, Activities of business, employers and professional membership organisations Support services; (7) Other service activities; Activities of business, employers and professional membership organisations; (8) Agriculture, forestry and fishing; Crop and animal production, hunting and related service activities; Growing of perennial crops; (9) Agriculture, forestry and fishing; crop and animal production, hunting and related service activities; plant propagation; (10) Agriculture, forestry and fishing; crop and animal production, hunting and related service activities; growing of non-perennial crops; (11) Agriculture, forestry and fishing; Animal production; (12) Manufacture of food products; Manufacture of prepared animal feeds; (13) Real estate activities; (14) Transportation and storage; Land transport and transport via pipelines + Warehousing and support activities for transportation; (15) Arts, entertainment and recreation; Sports activities and amusement and recreation activities; other amusement and recreation activities; (16) Construction; Construction of utility projects; (17) Financial and insurance activities; Other; (18) Public administration and defence; compulsory social security; Regulation of and contribution to more efficient operation of businesses.

About the author

Mersiha Tepić was born in 1982 in Zvornik, Bosnia-Herzegovina. In 2006 she received her Master degree in European studies at the Maastricht University in the Netherlands. With the specialisation in the field of external relations of the European Union, and interest in collaboration and public relations, she previously worked at an international and consulting office in Brussels and The Hague. Through this experience, her interest grew in the deployment of networks by different organizations and companies. As PhD candidate in Business Administration, at Wageningen University, she focused on the organisational firm capabilities which affect innovation performance in the context of in-house and network-oriented innovation projects. Within the Transforum Agro&Groen research project *Networking and governance strategies in agricultural innovation networks*, and in collaboration with Tilburg University, she performed case-study research on structural and relational governance mechanisms in networks where actors from the agri-food and life-sciences collaborate for the purpose of sustainability-oriented innovation. Within the European Union (EU) 6th Framework Q-pork chains project, she developed a large-scale survey to study the networking, absorptive capacity and innovativeness of pig farmers in the Netherlands. She disseminated her research (results) through presentations at several (inter)national conferences and workshops, and publications in among others the *Journal on Chain and Network Science*, and in Das, T.K. (ed.) Researching Strategic Alliances: Interpartner Dynamics in Strategic Alliances. She was distinguished with a Best Paper Award at the Workshop on Institutions and Organizations (2010) in Brazil with a paper titled *Governance in open innovation: Exploring the effect of innovation uncertainty and network heterogeneity* and the International Academy of Management and Business (IAMB) Conference (2010) in Spain with the paper titled *Structural and Relational Governance in open innovation projects in the Agri-food sector.*

Completed Training and Supervision Plan

Mersiha Tepic
PhD candidate, Wageningen School of Social Sciences (WASS)

Wageningen School of Social Sciences

Name of the activity	Department/Institute	Year	ECTS*
Project related courses and competences			
8th International Summer School on the Analysis of Political and Managerial Networks	Konstanz University Germany	2008	2
Innovation Networks and Alliance Management	TUE	2008-2009	5
Organization of the agri-business (BEC 31306)	WUR	2008	6
Presentations at conferences and workshops			
'The dynamics of network innovation projects: a comparative case-study in Agri-food industry'	National University of Maynooth, Ireland	2009	1
'(In-)formal governance in Agri-food open innovation projects'	Conference on Chain and Network Management, WUR	2010	1
'Structural and Relational Governance in open innovation projects in the Agri-food sector'	IAMB Conference, Complutense University, Madrid, Spain	2010	1
'Governance and performance in four types of Agri-food open innovation projects'	Performance measurement and corporate governance workshop, Scuola Superiore Sant'Anna, Pisa, Italy	2010	1
'Governance in open innovation- Exploring the effect of innovation uncertainty and network heterogeneity'	Research Workshop on Institutions and Organizations, Gonçalves, Brazil	2010	1
'The relation between information absorption and innovativeness of pig farmers'	Seminar Challenges for European Pork Chains, WUR	2011	1
'The impact of dynamic capabilities on innovation performance'	WASS PhD day	2011	1
General research related competences			
Mansholt Introduction course	WASS	2008	1.5
Research Methodology I: From topic to proposal	WASS	2008	4
Writing the research proposal	WASS		6
Quantitative Data Analysis: Multivariate Techniques (YRM 60306)	WASS	2009	6
Kwalitatieve analyse: Theorie en praktijk	Graduate School of Social and Behavioral Sciences Utrecht University	2010	1
Basic Statistics (MAT 14303)	WUR	2008	3
Basic statistics	PE & RC	2008	1.5
Questionnaire Construction (YRM-65300)	WUR	2009	-
Introduction Atlas.ti - tool for qualitative empirical research	WUR	2010	-
Career related competences/personal development			
PhD Competence Assessment	WGS	2009	0.3
Teaching and supervision activities	MST, WUR	2008 - 2011	4
Total (minimum 30 ECTS)			47.3

*One ECTS on average is equivalent to 28 hours of course work

The research described in this thesis was financially supported by the Dutch Ministry of Agriculture, Nature and Food Quality initiated innovation program Transforum Agro & Groen, as part of the scientific Transforum project titled *Networking and governance strategies in agricultural innovation networks: higher order impacts and ways of coping*. The research was also financially supported by the EU under the 6th Framework Program for Research, Technological Development and Demonstration Activities, through the project Q-porkchains FOOD-CT-2007-036245. The content of the thesis reflects only the views of the author. The two funding parties did not have a role in the process of conducting interviews, analysis and interpretation of the data.

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