INTER-ORGANIZATIONAL COOPERATION AND INNOVATION:

AN EMPIRICAL ANALYSIS OF PARTNER CHARACTERISTICS AND INNOVATION BASED ON CIS DATA

Master's thesis *Delft, October 2007*

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Preface

Before you lies my master's thesis report, the final requirement for graduation at the Management of Technology master's program at the Delft university of Technology (TU Delft). The Management of Technology master's program is organized by the faculty of Technology, Policy and Management at TU Delft.

This thesis was prepared in cooperation with the Dutch central bureau of statistics, which have ownership over the data on the results of the Dutch Community Innovation Survey (CIS). The CIS survey is a European initiative to monitor innovation progress throughout the European Union based on firm level innovation data. The Dutch CIS dataset was the main data source for the statistical analysis that is provided in this thesis.

The official kick-off for this master's research project was held in April 2007. The project was supervised by representatives from Economics of Innovation and Technology, Strategy and Entrepreneurship sections at the faculty of Technology, Policy and Management at TU Delft. This research is to be presented, defended and evaluated on November 2nd, 2007 at room F of the faculty of Technology, Policy and Management.

In this preface I would like to thank all my friends and family, who supported and encouraged me during the realization of my thesis. Special thanks go out to my supervisors, Dr. Cees van Beers, Dr. Erik den Hartigh and Fardad Zand Msc., for their stimulating guidance, flexibility and insights during the research project. I would also like to thank Dr. Ronald Dekker and Robert Vergeer Msc. for sharing their expertise on some statistical issues. Finally, my thanks also go out to the staff of the Dutch central bureau of statistics for their hospitality and cooperation throughout my research.

René Wevers

Rotterdam, October 2007

Executive summary

In the turbulent business environment that has developed, inter-organizational (R&D) cooperation has become an increasingly popular strategy in developing and commercializing innovation. Nevertheless, many uncertainties still exits surrounding the effects and management of inter-organizational cooperation which is underlined by the high failure rates of cooperative efforts. This study attempts to provide more insight on the relation between inter-organizational cooperation and innovation, based on Community Innovation Survey (CIS) data. More specifically, the study tries to empirically establish relations between partner characteristics in inter-organizational cooperation.

In explaining and hypothesizing the effects of cooperation on innovation the study applies a knowledge based perspective, assuming that knowledge is the most valuable resource that is accessed or acquired through cooperation. Furthermore the study applies a multidimensional measurement for innovation, distinguishing between innovation intensity, innovation success and innovation novelty. From an extensive literature review hypotheses were postulated on the effects of type and diversity of cooperation partners on these three dimensions of innovation.

The CIS database that was analyzed to test the hypotheses contained firm level innovation data on 3090 product innovators. The obtained results from the empirical analysis indicated that different types of cooperation partners had significantly different effects on innovation. This suggests that partner characteristics in (R&D) cooperation matter for innovation. This finding emphasizes the need for better cooperation portfolio management for organizations.

Another interesting finding was that cooperation with customers was found to be beneficial for all of the dimensions of innovation, whereas cooperation with suppliers was found to be detrimental for all of these dimensions. This opposes much of the current literature which generally considers cooperation with suppliers a positive influence on innovation and where often cooperation with customers and suppliers is often grouped under the term ‘vertical cooperation’.

Furthermore, cooperation with public science partners was found to have a positive effect on innovation intensity and innovation novelty. Similarly, cooperation with geographically diverse partners was found to have a positive effect on innovation intensity and innovation novelty as well. This latter finding is in support of the theoretical notion that diversity is important for organizational learning and provides a basis for further research on diversity in cooperation and innovation.

Finally, the research also provided evidence that absorptive capacity in certain cases intensifies the effects of cooperation on innovation. This suggests that the ability to create value from cooperation is at least partly an organization specific quality. Further research on this subject is recommended.

Table of contents

Preface III

Executive summary V

Table of contents VII

List of figures and tables XI

Figures XI

Tables XII

1. Introduction 1

1.1. Scope 2

1.2. Relevance and contribution 2

1.3. Problem definition and research questions 3

1.4. Research approach 5

1.4.1. Explorative phase 5

1.4.2. Empirical phase 6

1.4.3. Round-up 7

1.4.4. Time table 7

1.5. Outline of the report 7

2. The concept of inter-organizational cooperation 9

2.1. Types of inter-organizational cooperation 10

2.2. Level of analysis 11

2.3. Perspectives and theories on R&D cooperation 12

2.3.1. Transaction Cost Economies (TCE) 12

2.3.2. Resource Based View (RBV) 13

2.3.3. Social Network Analysis (SNA) 14

2.3.4. Learning perspectives and cognitive theory 14

2.3.5. Evaluation of the theories and perspectives 16

2.4. Partner typology 17

2.4.1. Stakeholder type 18

2.4.2. Geographic location 21

2.5. Diversity of cooperation partners 22

3. Conceptualization of innovation 25

3.1. Defining innovation 25

3.2. Exploration vs. exploitation 26

3.2.1. Exploration and exploitation in cooperation 27

3.2.2. Innovation intensity vs. innovation success 28

3.3. Innovation typology 30

3.3.1. Product, process and organizational innovation 31

3.3.2. Radical vs. incremental innovation 32

4. Inter-organizational cooperation and innovation 35

4.1. R&D Cooperation and innovation in general 35

4.2. Theory on partner types and innovation 36

4.2.1. The role of customers 37

4.2.2. The role of suppliers 38

4.2.3. The role of competitors 39

4.2.4. The role of science partners 40

Difference between private and public science partners 41

4.3. Theory on partner diversity and innovation 42

4.3.1. Meaningful diversity 43

Stakeholder diversity 43

Geographic diversity 44

4.4. Absorptive capacity 45

5. Conceptual framework and hypotheses 47

5.1. Knowledge based theoretical framework 47

5.2. Hypotheses 49

Customer cooperation 49

Supplier cooperation 50

Competitor cooperation 50

Private science partner cooperation 51

Public science partner cooperation 52

Diversity of type of cooperation partners 53

Absorptive capacity 54

6. Research methodology 57

6.1. Community Innovation Survey (CIS) 57

6.2. Measurement 58

6.2.1. Dependent variables 58
Innovation intensity 58
Innovation success 59
Innovation novelty 60
6.2.2. Independent variables 62
Stakeholder type of cooperation partners 62
Diversity of partner types 63
Absorptive capacity 65
6.2.3. Control variables 66

6.3. Statistical methods and models 68

6.3.1. Statistical models 69

7. Empirical results 71

7.1. Descriptive statistics 71

7.2. Interval regression models 75

7.2.1. Interval regression models with product terms 75
7.2.2. Innovation intensity 77
Innovation intensity 1 77
Innovation intensity 2 79
Comparison and overall result 82
7.2.3. Innovation success 82
7.2.4. Innovation novelty 85
Innovation novelty 1 85
Innovation novelty 2 88
Comparison and overall result 89

8. Discussion and conclusions 91

8.1. Summary of results and theoretical reflection 91

8.2. Research limitations 96

8.2.1. Data limitations 96
8.2.2. Measurement limitations 97
8.2.3. Causality 99

8.3. Implications and recommendations 100

8.3.1. Managerial implications 100
8.3.2. Recommendations for further research 101
8.3.3. Recommendations for CIS survey 102

References 105

Appendix A: Literature overview 117

Literature on cooperation and innovation in general 117
Literature on the role of customers 118
Literature on the role of suppliers 119
Literature on the role of competitors 120
Literature on the role of science partners 120
Literature on the difference of public and private science partners 121
Literature on diversity of partners in general 122
Literature on stakeholder diversity 123
Literature on geographic diversity 123

Appendix B: R&D expenditure regression over years 125

Appendix C: CIS survey 127

Appendix D: SBI '93 industry sector classification 137

Appendix E: Descriptive plots of dependent variables 139

Descriptive plots of dependent variables 139

Appendix F: Interval regression models 143

Innovation intensity 1 complete models 144
Innovation intensity 1 stepwise models 145
Innovation intensity 2 complete models 147
Innovation intensity 2 stepwise models 148
Innovation success complete models 150
Innovation success stepwise models 151
Innovation novelty 1 complete models 152
Innovation novelty 1 stepwise models 153
Innovation novelty 2 complete models 155
Innovation novelty 2 stepwise models 156

Appendix G: Plots of amount of cooperation per partner type 159

List of figures and tables

Figures

Figure 1-1 Schematic overview of research methodology 6

Figure 2-1 Schematic representation of the focus of the research in the field of inter-organizational cooperation 10

Figure 2-2 Schematic overview of the interaction between cognitive distance and learning 15

Figure 2-3 Types of innovation stakeholders according to Gemünden and Ritter (Gemünden, Ritter et al. 1996; Ritter and Gemunden 2003) 19

Figure 2-4 Stakeholder typology applied for the research 21

Figure 3-1 Rothaermel's product development path based on alliances (Rothaermel and Deeds 2004) 28

Figure 5-1 A knowledge based model on cooperation and innovation 48

Figure 5-2 Customer cooperation and innovation from the knowledge based view 49

Figure 5-3 Supplier cooperation and innovation from the knowldge based view 50

Figure 5-4 Competitor cooperation and innovation (solely) from the knowledge based view 51

Figure 5-5 Private science partner cooperation and innovation from knowledge based view 51

Figure 5-6 Public science partner cooperation and innovation from knowledge based view 52

Figure 5-7 (Any type of) Partner diversity and innovation from the knowledge based view 53

Figure 5-8 Research model for empirical investigation 54

Figure 7-1 Frequency of stakeholder types of cooperation partners 72

Figure 7-2 Frequency of geographic location of cooperation partners 73

Figure 7-3 Distribution plot for stakeholder diversity of partners 73

Figure 7-4 Distribution plot for geographic diversity of partners 74

Figure 7-5 Distribution of organizations´ industry sectors throughout the sample 74

Tables

Table 1-1 Time table for the research 7

Table 1-2 Overview of chapter topics in relation to the research questions 8

Table 2-1 Applied stakeholder typology with the link to the typology by Gemünden and practical examples of the types of organizations as according to the CIS survey 20

Table 6-1 Description and measurement of variables 67

Table 6-2 Overview of the relevant (interval) regression models 69

Table 7-1 Descriptive statistics 71

Table 7-2 Interval regression results with dependent variable innovation intensity 1 77

Table 7-3 Interval regression results with dependent variable innovation intensity 2 80

Table 7-4 Interval regression results with dependent variable innovation success 83

Table 7-5 Interval regression result with dependent variable innovation novelty 1 86

Table 7-6 Interval regression result with dependent variable innovation novelty 2 88

Table 8-1 Summary of the results of the emperical analysis in relation to the hypotheses 92

1. Introduction

Economists have been aware of the relevance of innovation for economic change all the way back to Schumpeter. Since then many theories have been developed on the subject of innovation and its role for individual companies. Nowadays, with the turbulent business environment that has developed, innovative capacity is considered to be one of the main drivers of firm performance (Tidd, Bessant et al. 2005). With the information age presenting itself over the last decades, a transition from mass production to mass customization (Kotha 1995) and growing emphasis on time-based competition (Stalk 1988) have resulted in huge innovation pressure for firms. Parallel to this, increasing product complexity has led to increased costs and risks for innovators and a need for multi-disciplinary development teams. This has led to a situation in which many firms are not capable or prepared to bare the risks of innovation by themselves. As a result 'go it alone' R&D strategies are being replaced by R&D cooperation strategies leading up to 'innovation networks'. Networking has become an increasingly important business activity, which is underlined by a spectacular growth in strategic alliances (Duysters and de Man 2003) with R&D partnerships in particular (Hagedoorn 2002). However, this spectacular growth in (R&D) alliances and the mentioned benefits of cooperation are accompanied by extremely high failure rates, which desperately calls for better management and selection of alliances (Ireland, Hitt et al. 2002; Rothaermel and Deeds 2006).

In recent years the awareness of the economic importance of technology and innovation has lead to an initiative by the European Innovation Monitoring System (EIMS) and Eurostat to collect firm level data on innovation throughout the European Union. These Community Innovation Surveys (CIS) provide a unique basis to empirically investigate drivers and effects of innovation. In the most recent versions of the CIS, this includes data on cooperation in innovation activities.

On basis of the CIS surveys for The Netherlands accumulated by the Dutch central bureau of statistics (CBS), this study attempts to provide more insight on the relation between inter-organizational (R&D) cooperation and innovation. It does so by linking (R&D) cooperation partner characteristics to innovation measures. Furthermore, the study makes a first step in analyzing effects of partner portfolio or composition by linking the diversity of (R&D) cooperation partners to innovation measures.

1.1. Scope

The research was conducted on the basis of a pre-existing CIS dataset from CBS, containing data on innovation activities and output for over 10.000 enterprises stationed in the Netherlands. Where for this research only product innovators are of interest, as will be discussed in chapter 3.3.1, the sample was reduced to 3090 product innovators in the database. The CIS data is representative for the research, but does set certain limitations or boundaries.

The CIS database at CBS contains data from surveys conducted over the years 1994-2004. However, only the surveys containing information on cooperation are applicable for the research limiting the time span to 1998-2004. The main focus will be on the 2002-2004 survey, integrating certain data and elements from previous surveys. The empirical analysis will be conducted cross-sectional and on firm level.

Since the research is based on data from the Dutch CIS surveys, the results for this study are mainly representative for organizations located in the Netherlands.

Data on cooperation provided from the CIS surveys can be expected to only portray formal R&D cooperation agreements between organizations. Therefore data on informal inter-organizational cooperation or cooperation agreements not involving R&D is not available and therefore outside the scope of this research. This is discussed in more detail in chapter 2.1.

1.2. Relevance and contribution

In recent years the effects of inter-organizational cooperation have become an increasingly important research topic. However, much of the research in this field has been directed towards the overall effects of cooperation on firm performance (Hagedoorn and Schakenraad 1994; Gulati 1998; Combs and David J. Ketchen 1999; Stuart 2000). This work has provided many insights in the subject, but mostly at a general and abstract level. In recent years research efforts have been more focused, linking cooperation to specific business activities, with innovation in particular (Powell, Koput et al. 1996; Baum, Calabrese et al. 2000; Pittaway, Robertson et al. 2004). This and other work on cooperation and innovation has provided relevant insights on the effects of (R&D) cooperation on innovation, which has led to an

awareness of the need for alliance portfolio management. However, the appropriate theory to be applied in practical tools or models has yet to be developed.

This empirical study attempts to confirm and extend existing literature on cooperation and innovation by utilizing the huge, reliable dataset that was developed through the CIS surveys. Although comparable studies have been performed in several countries, this is the first time such a study will be conducted on the basis of Dutch CIS data. Also the research distinguishes itself with a multidimensional approach to the measurement of innovation, analyzing innovation activity on three dimensions: innovation intensity, commercial success of innovation and (market) novelty of innovation. With this unique approach the research provides a specific contribution to both theory and practice on cooperation in innovation.

Scientifically, the study provides empirical confirmation or rejection of current literature in the field and adds to results found in other countries or based on different datasets. Also the multidimensional approach towards innovation will provide a broader view on the effects of partner characteristics and selection as have been studied in previous work. Moreover, the research contains a first attempt to investigate the effects of partner composition on innovation based on CIS data, by analyzing the effect of partner diversity on innovation.

Practically, by applying a generally accepted and comprehensible typology of partner characteristics, the research could easily be integrated in managerial practice. Insights from the research can help in creating a first basis for developing tools and models to apply in partner selection and alliance portfolio management. The relevant insights provide managers with a better understanding of the effects of an R&D partnership and as such enables them to more consciously select their partners and obtain maximum value from their R&D partnerships. As such the research might reduce certain risks in R&D cooperation and thus reduce the barriers for organizations to innovate or cooperate in innovation.

1.3. Problem definition and research questions

The overall goal of the research is to provide more insight in the relation between inter-organizational R&D cooperation and innovation. Practically this should lead to an improvement in managerial practices surrounding cooperation (portfolio) management and selection.

To obtain this goal an empirical study will be conducted linking specific partner characteristics to innovation on the basis of CIS data.

The main research question to obtain the goal of this research is therefore:

What is the relation between partner characteristics in inter-organizational R&D cooperation and organizations' innovation activities and outputs?

To answer this question it has to be divided into several sub-questions:

1) What is inter-organizational (R&D) cooperation?
   a) What types of inter-organizational (R&D) cooperation can be identified?
   b) What are the present theories applied in analyzing inter-organizational (R&D) cooperation?
   c) What are relevant characteristics of partners in inter-organizational (R&D) cooperation?
   d) What are relevant typologies of partners in inter-organizational (R&D) cooperation?
   e) Which of the typologies are suitable and applicable for the research?
   f) What does diversity of partners mean in inter-organizational (R&D) cooperation?

2) What is innovation?
   a) What are relevant typologies or dimensions in conceptualizing innovation activities or outputs?
   b) Which of the innovation dimensions are suitable and applicable for the research?

3) What is the relation between inter-organizational (R&D) cooperation and innovation according to the literature?
   a) How are the different types of partners in inter-organizational (R&D) cooperation expected to affect innovation?
   b) How is partner diversity in inter-organizational (R&D) cooperation expected to affect innovation?

4) How can the hypothesized relations between inter-organizational (R&D) cooperation and innovation be tested empirically?
   a) What data sources will be utilized for empirical testing?
   b) How is partner typology measured from the data?
   c) How is partner diversity measured from the data?
   d) How are the innovation dimensions measured from the data?

5) What can be interpreted from the results of the (empirical) research?
   a) What can be concluded about the relations between inter-organizational (R&D) cooperation and innovation?
   b) What are the Limitations of the research?
   c) What are the (managerial) implications and recommendations of the research?

1.4. Research approach

To be able to answer the research questions, the appropriate research methodology will be explained in this chapter. Effectively, the research will be separated into two main complementary phases: An explorative phase in which the conceptual framework will be created and an empirical phase in which this framework will be tested. This research strategy will mainly be based on quantitative research methods. The strategy and data collection methods that should be applied will be explained per phase.

1.4.1. Explorative phase

This phase is all about aggregating the necessary theory to be able to develop a relevant conceptual framework and hypotheses to be tested in the empirical phase of the research. Also the necessary expertise on the subject is developed to be able to select the right tools and data for the empirical phase.

This phase will mainly comprise an extensive literature review on the relevant fields of inter-organizational cooperation and innovation. Literature on these subjects

will be accumulated and (re-)interpreted to provide the basis of the research. From this literature basis a conceptual framework is built and hypotheses are drawn.

1.4.2. Empirical phase

This phase is all about testing (part of) the conceptual framework on empirical data. In this phase the hypotheses that were generated in the explorative phase will be proven or disproved, although unexpected new results can also be generated.

Naturally this phase calls for a data collection method to gather empirical data on the subject. Fortunately, the CIS data from CBS provides a huge and reliable dataset which is suitable for this type of research. Developing and sending out questionnaires specifically for this research would not have been possible in the available time span and would have had a much lower respondent rate. Although the CIS data is not tailor made for this research, it is properly applicable and of high reliability. Therefore the main data source for the research was the CIS database at CBS. For this research phase it will also be important to study the available data and select a representative set of measurements, which will require more literature reviewing.

Once the data and measurements are available, representative samples should be selected from the data to do quantitative (statistical) analysis. Results from this analysis should be carefully interpreted to provide the conclusions of the research, as well as further recommendations.

At the end of this phase the research is more or less complete and a final report can be drawn up and reviewed.

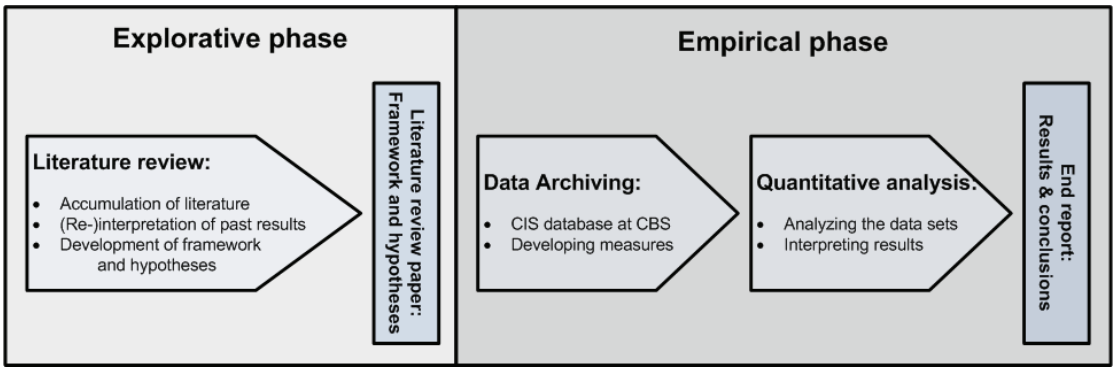

Figure 1-1 Schematic overview of research methodology

1.4.3. Round-up

Although it is outside the direct scope of the research project, if results of the research are of high scientific or practical value they should be disseminated. This should be taken in account when applying and completing the research. Also after the final report is finished and approved, there will be a concluding presentation.

1.4.4. Time table

The activities within the research methodology as described in previous paragraphs have to follow a schedule with some deadlines. This schedule is presented in Table 1-1, in which the deadlines are denoted by numbers that represent the following:

1. Draft paper on literature review and conceptual framework
2. Approved paper on literature review and conceptual framework
3. Draft of final report
4. Final report

Table 1-1 Time table for the research

	April				May			June						July		August							September				October			
Weeks	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
Explorative Phase																													
Literature study																													
Formulating Framework																													
-preparing draft version																													
-integrating feedback																													
Emperical Phase																													
Data Archiving																													
-selecting data																													
-developing measures																													
Quantitative analysis																													
-analyzing data																													
-interpreting results																													
Finalization final report																													
-preparing draft version																													
-integrating feedback																													
													1		2									3				4		

1.5. Outline of the report

The outline of the report largely follows the research questions as they were presented in paragraph 1.3. This is schematically shown in Table 1-2 where the research questions are mapped to the corresponding chapters of the report.

Chapter 2 discusses the concept of inter-organizational cooperation, by exploring some relevant classifications and perspectives on the subject of inter-organizational

cooperation. Also the typology of partners in inter-organizational cooperation is discussed and some theory on the diversity of cooperation partners is provided. Chapter 3 takes a closer look at innovation by discussing some definitions and typologies from innovation literature. Also the organizational learning perspective of exploration vs. exploitation is introduced to establish the link between innovation and (external) knowledge. Chapter 4 explains the theoretical relationships between inter-organizational cooperation and innovation, mainly by discussing the effects on innovation per type of cooperation partner and partner diversity. Also the notion of absorptive capacity is introduced here. Chapter 5 formulates a theoretical model on inter-organizational cooperation and innovation and postulates the research hypotheses based on the theoretical model. Chapter 6 discusses the research methodology with the measurement of the research variables in particular. Chapter 7 provides the results of the empirical analysis, including additional explanation on how the hypotheses are tested. Finally, chapter 8 discusses the main findings and limitations of the research and translates these into some relevant managerial implications and recommendations for further research.

Table 1-2 Overview of chapter topics in relation to the research questions

Question nr.	Research question	Data	Chapter(s)
1	What is (R&D) cooperation?	Literature	2
2	What is innovation?	Literature	3
3	What is the relation between (R&D) cooperation and innovation according to the literature?	Literature	4 + 5
4	How can the hypothesized relations between (R&D) cooperation and innovation be tested empirically?	Survey data	6 +7
5	What can be interpreted from the results of the (empirical) research?	Survey data	8

2. The concept of inter-organizational cooperation

Cooperation is a very broad definition. If we look in the dictionary, it is as follows (Dictionary.com 2007):

co·op·er·a·tion [koh-op-uh-rey-shuhn] –noun

1) An act or instance of working or acting together for a common purpose or benefit; joint action.
2) More or less active assistance from a person, organization, etc.: We sought the cooperation of various civic leaders.
3) Willingness to cooperate: to indicate cooperation.
4) *Economics*. The combination of persons for purposes of production, purchase, or distribution for their joint benefit: producers' cooperation; consumers' cooperation.
5) *Sociology*. Activity shared for mutual benefit.
6) *Ecology*. Mutually beneficial interaction among organisms living in a limited area.

Where this research has a clear focus on cooperation between organizations, the above definition can be narrowed down to inter-organizational cooperation as being:

The practice of multiple organizations working together for a common purpose or benefit

However, to get a clear idea on the concept of inter-organizational cooperation as it will be applied in the research much has to be explained. This chapter attempts to narrow down the broad definition of inter-organizational cooperation to the context of the research by explaining the different aspects and perspectives surrounding inter-organizational cooperation and elaborating on which of these aspects and perspectives are relevant in an innovation context.

2.1. Types of inter-organizational cooperation

Inter-organizational cooperation is present in practically all types of business activities, exists in many different forms and has many more different characteristics. To narrow down in what part of the field this research presents itself, several typologies for inter-organizational cooperation will be discussed.

The most fundamental typology for inter-organizational cooperation is based on the type of business function they have or correspond with. Roughly this can be separated into three global categories: research and development, manufacturing and marketing & sales (Powell, Koput et al. 1996; Dussauge, Garrette et al. 2000). In R&D cooperation the purpose of the cooperation is to create innovation, examples are co-development or innovation networks. Cooperation in manufacturing is aimed at improving production processes and is often cost driven, examples are supplier relations or joint manufacturing. Cooperation in marketing and sales is directed to improving market position and image of the cooperation, examples are joint advertising or licensing. The function of an inter-organizational cooperation can be related to one or more of the three categories as described above. For this study only the R&D function is relevant and thus only cooperation with a certain involvement in innovation activities is analyzed.

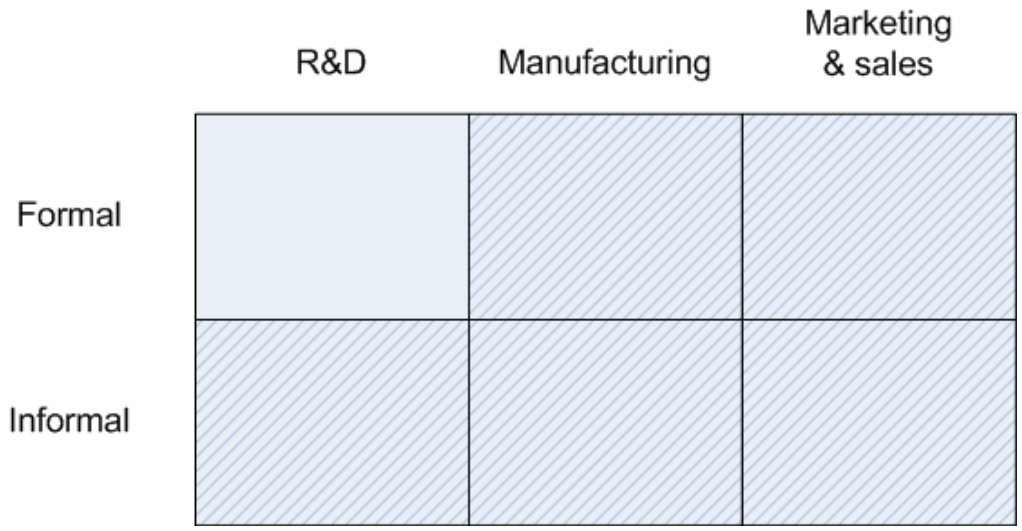

Figure 2-1 Schematic representation of the focus of the research in the field of inter-organizational cooperation

Another distinction in inter-organizational cooperation is that between formal and informal cooperation. Formal cooperation is characterized by contractual agreements and informal cooperation consists of casual, unofficial communication between

organization's employees. Many studies have found that informal cooperation is just as relevant as formal cooperation, especially in the field of knowledge diffusion (von Hippel 1987). However, empirical data on informal cooperation was not present in the dataset applied for this research and is hard to obtain in general. Therefore the focus of this study is on formal cooperation agreements.

This focus in terms of the discussed types of inter-organizational cooperation is schematically shown in Figure 2-1. In this figure the shaded parts denote the types of cooperation that fall outside of the scope of this research.

2.2. Level of analysis

An important issue in researching inter-organizational cooperation is the level of analysis that is applied. Where traditionally inter-organizational cooperation was purely analyzed as a relation between two individual parties, recent theories have developed a bigger view interpreting inter-organizational cooperation as organizational networks (Gulati 1995; Powell, Koput et al. 1996; Gulati 1998). With this interpretation of inter-organizational cooperation as organizational networks a clear distinction is necessary between the different levels of analysis. When analyzing organizational networks the most obvious distinction is between the following three levels of analysis (Borgatti and Foster 2003):

- *Actor level* – Analyzing the attributes that can bestowed upon individual actors.
- *Dyadic level* – Analyzing the attributes of relationships between pairs of actors.
- *Network level* – Analyzing the attributes of networks of actors, like network structure.

Important to note here is that with each level the complexity increases, so actor level is the least complex, then come dyadic level and network level is the most complex. More importantly, the availability and tangibility of data for the different levels decreases with this complexity. Due to the available and tangible data on actor level analysis, this study will be conducted on actor level, by analyzing the relation between partner characteristics and innovation for organizations.

2.3. Perspectives and theories on R&D cooperation

R&D cooperation is surrounded by many different theories and perspectives. Although these theories largely seem incompatible or contradictory, they each contain relevant insights on the subject of R&D cooperation. The theories and perspectives that were found to be dominant throughout the literature and relevant to the subject will be discussed in this paragraph.

2.3.1. Transaction Cost Economies (TCE)

The transaction cost approach to the study of economic organization regards the transaction as the basic unit of analysis and holds that an understanding of transaction cost economizing is central to the study of organizations (Williamson 1981; Williamson 1985). In relation to inter-organizational cooperation the TCE perspective argues that to determine whether to engage in cooperation and what type of cooperation depends on the anticipated transaction costs of the cooperation. These transaction costs are twofold. Firstly the transaction or cooperation involves certain levels of uncertainty and risks about opportunistic behavior from one of the parties. Secondly, stemming from concerns about such uncertainty and risks, are the costs made in governance or coordination of the transaction, like costs from negotiation and contractual agreements (Gulati 1995; Gulati 1998). The original essence of Williamson's theory is that based upon this, transactions which are subject to uncertainty and which require substantial 'transaction-specific investments' are likely take place within the hierarchy of the firm (governance through vertical integration). Alternatively, transactions of less uncertainty and requiring few 'transaction-specific investments' are likely to take place based on market contracting (governance through price mechanism) (Robertson and Gatignon 1998). Basically, in traditional TCE the central concern is identifying transactions that minimize the costs of governance which, in turn, maximize performance (Combs and David J. Ketchen 1999).

More recent efforts on explaining cooperation from the TCE perspective, however, argue that the transaction costs or disadvantages have to be weighted against possible benefits of cooperation (Gulati 1995). Even with the adaptations, the TCE reasoning is highly driven from risk and efficiency motives and as such is criticized often in the literature for not capturing the social and strategic motives for cooperation

(Eisenhardt and Schoonhoven 1996; Ghoshal and Moran 1996). Especially in R&D cooperation the motives and advantages for the cooperation go beyond the transaction costs involved.

2.3.2. Resource Based View (RBV)

A completely different view is the resource based view (RBV) which argues that the basis for an organization's competitive advantage mainly lies in the valuable resources the firm has at its disposal and how these are applied (Wernerfelt 1984). This notion was extended by Barney (Barney 1991) by elaborating that for a resource to have the potential of generating competitive advantage, it must be:

- Valuable, in the sense that it exploits opportunities and/or neutralizes threats in an organization's environment.
- Rare in the current and potential competitive environment.
- Imperfectly imitable
- Imperfectly substitutable

Also in order to transform a short-run competitive advantage into a sustained competitive advantage requires that the resources are heterogeneous in nature and not perfectly mobile (Barney 1991). These resources consist of both assets and capabilities.

From the RBV perspective cooperation is seen as a resource that helps the organization to increase value by pooling and integrating its resources with those of other firms (Das and Teng 2000; Barney, Wright et al. 2001). In fact, a firm's cooperation network can be thought of as creating inimitable and non substitutable value (and constraint!) as an inimitable resource by itself, and as a means to access inimitable resources and capabilities (Gulati, Nohria et al. 2000).

An interesting extension of RBV is the more recent knowledge based view (KBV). KBV extends the RBV by considering knowledge is the most strategically significant resource for an organization. KBV argues that knowledge is highly complex and unique in nature and therefore very difficult to imitate. Also it is argued that knowledge allows for coordinating traditional resources to create more value than their competitors (Kogut and Zander 1992; Grant 1996; Spender 1996). From KBV point of view the main objective for cooperation is accessing knowledge (Grant and Baden-Fuller 2004). Especially in R&D cooperation the notion of knowledge being

the most valuable resource for an organization seems to be relevant, since R&D is a highly knowledge intensive activity. Also when identifying important motives for cooperation in R&D knowledge related issues are often mentioned, like obtaining access to new technologies and pooling complementary skills (Pittaway, Robertson et al. 2004).

2.3.3. Social Network Analysis (SNA)

The social network analysis (SNA) perspective is a relatively new approach to analyze inter-organizational cooperation, although it has been around for quite some time in the field of sociology. In the business field SNA supporters acknowledge insights from the RBV and TCE perspectives, but criticize that these perspectives focus on the organization or alliance as a unit of analysis not taking into account the cooperative actions of other organizations or the relationships in which the organizations themselves are already embedded. It is argued that incorporating networks into the analysis leads to a more comprehensive view of the (strategic) behavior of organizations (Burt 1995; Gulati 1995; Rowley 1997; Gulati 1998; Burt 2000; Gulati, Nohria et al. 2000).

As was discussed in the paragraph on levels of analysis, a network perspective not only incorporates effects on actor level and relationship level, but also takes into account or even focuses on effects on the network level. As such the SNA perspective integrates attributes on network structure, network composition and network position into the analysis of inter-organization cooperation and provides a more extensive analysis of the relationships or ties between the actors based on network theory.

2.3.4. Learning perspectives and cognitive theory

With a strong connection to the earlier mentioned knowledge based view of the organization, another interesting perspective on cooperation comes from the field of psychology by analyzing learning processes. With knowledge being the most valuable resource for organizations, the learning process becomes undoubtedly involved in inter-organizational cooperation. Analyzing the learning process in inter-organizational cooperation has led to an interesting notion of a trade-off in the extent that resources or knowledge between cooperating organizations are compatible

(similar) or complementary (Mowery, Oxley et al. 1998; Das and Teng 2000). High similarity or compatibility of resources and knowledge should lead to high efficiency, but low value of cooperation. Highly differentiated or complementary resources on the other hand should bring high value, but low efficiency (Parkhe 1991; Das and Teng 2000).

This notion has been extended by Nooteboom (Nooteboom 1999) into a cognitive theory of inter-organizational cooperation, in which he introduces the term cognitive distance. He states that knowledge is path dependent and thus that past experience and interaction determine the mental category or cognitive framework of an individual or organization. He argues that there will be 'cognitive distance' between actors with different experiences and 'cognitive proximity' between actors with similar or shared experience. Where learning usually takes place when an actor interacts with others that see or do things differently, cognitive distance is needed to learn something new and come to novel solutions. However, cognitive distance can not be too large in order for actors to understand one another. A trade-off arises between cognitive distance, for the sake of novelty, and cognitive proximity, for the sake of understanding and utilization of complementary knowledge (Nooteboom 1999; Nooteboom 2003). In this trade-off there is logically an optimal cognitive distance in which learning performance is best. This trade-off is schematically portrayed in Figure 2-2.

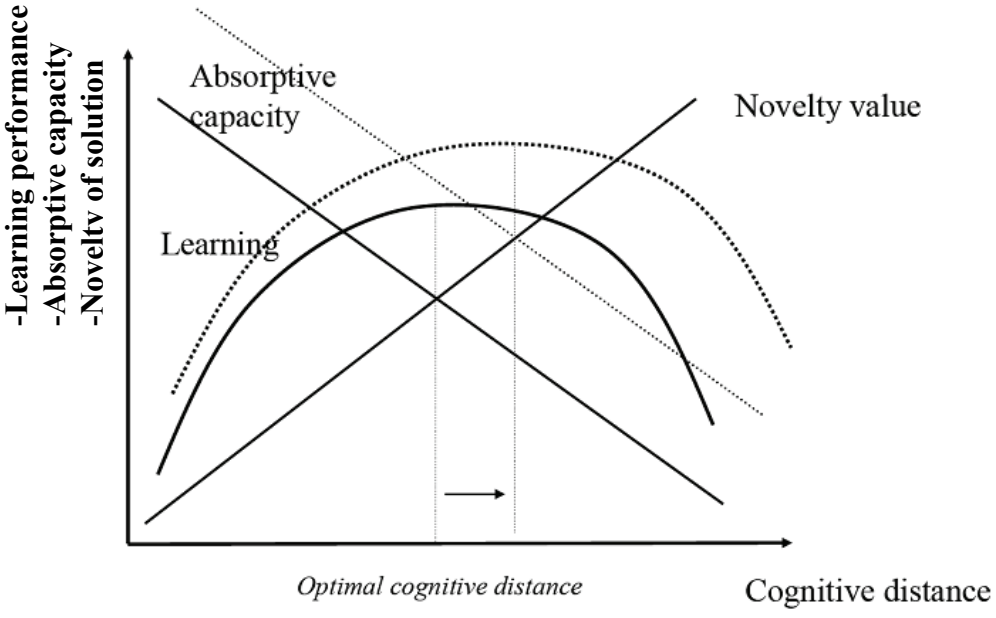

Figure 2-2 Schematic overview of the interaction between cognitive distance and learning

The optimal cognitive distance however, is also dependent on an actor's ability to cross the cognitive distance, the absorptive capacity of that actor. Absorptive capacity entails the ability to empathize, i.e. the generalized, non-relation-specific ability to access the thinking of others without thinking alike (Nooteboom 2003). An actor with larger absorptive capacity can understand knowledge from a larger cognitive distance and thus has a higher optimal cognitive distance and higher learning performance. This is portrayed in Figure 2-2 by the dotted lines.

2.3.5. Evaluation of the theories and perspectives

In evaluating the theories and perspectives discussed in this chapter there are some important factors to take in account. The main factor here is that the theories should fit the objectives and context of the research, namely that of establishing a link between (R&D) cooperation and innovation.

The TCE perspective is clearly important in analyzing inter-organizational cooperation, but it provides a static view of cooperation by assuming that at a certain time the benefits and costs for cooperation can be accurately determined to assess the added value of cooperation. This static perspective does not fit in the context of analyzing cooperation and innovation, where effects and benefits are highly uncertain. Nevertheless the TCE perspective could provide relevant insights on unexpected results and when possible should be taken into account.

The RBV and mainly KBV perspectives can be argued to be highly relevant in the context of innovation, where (specific, unique) knowledge or resources have a strong influence. Access to external knowledge and capabilities plays a big role in R&D activities, as well as governing and extending internal knowledge. These perspectives are therefore suitable to provide a basis for the theoretical framework of this research.

The SNA perspective is a recent and relevant theory in analyzing inter-organizational cooperation, but the level of analysis and complexity are mostly outside the scope of this research. Nevertheless it is naturally important to take into account that inter-organizational cooperation goes beyond dyadic cooperation agreements. Furthermore this perspective can provide a better understanding of the relevance of diversity and might provide insights to explain certain unexpected results. Although at present it is not feasible to include network level effects of inter-

organizational cooperation in this empirical study, it is a logical next step for further research on the subject of cooperation and innovation.

The cognitive theory by Nooteboom, like KBV, is highly relevant in the context of innovation, where (specific, unique) knowledge has a strong influence. Where KBV focuses on the access to specific knowledge sources, the cognitive theory can explain the value of those knowledge sources by integrating learning effects. This theory fits the KBV nicely to provide a knowledge based theory basis for the research model and hypotheses.

Based on the argumentation above, a combination of the KBV and cognitive theory seems the most suitable theory basis in explaining the role of cooperation in innovation. In this, the perspectives of TCE and SNA can still prove to be relevant by providing extended explanation of certain topics and unexpected results.

2.4. Partner typology

As was discussed in the introduction and the paragraph on levels of analysis, the analysis of (R&D) cooperation is mainly focused on partner characteristics. This requires a relevant typology of the partners. In the literature on inter-organizational cooperation the most important and reoccurring typologies of partners are the industrial (technological) sector, the position in the supply chain or stakeholder type, the geographic (cultural) location and the size or power of the organizations involved (Chiesa and Manzini 1998). The available CIS data set only provides information on the stakeholder type and the geographic location of partners, which limits the analysis of diversity to these two types of diversity for this study. More explanation on the exact relevance of these typologies in an innovation context will be provided in chapter 4. In this chapter only the type of categorization is discussed.

From the typologies that could not be analyzed, the industry sector of partners could still be relevant, especially from the earlier discussed views about compatible vs. complementary knowledge and cognitive distance. From these views different industry sectors mean different (technological) knowledge pools and corresponding learning effects.

In the case of size and power of partners, the distinction does not seem very relevant at first glance. Nevertheless it might be argued that larger, more powerful organizations have ownership of and access to more and diverse resources or

knowledge where smaller partners can be argued to be more flexible and creative in applying and producing knowledge.

In summary, each of the typologies of partners that were mentioned above could prove relevant in the context of the research. Due to data limitations nevertheless this research will have to refrain itself to only analyze effects based on the typologies of stakeholder type and geographic location of partners, which will be discussed in more detail in the following paragraphs.

2.4.1. Stakeholder type

Since the research examines R&D cooperation, the only stakeholders that are relevant in this context are those that have a (direct) influence in the R&D process. Dependent on the level of detail, this can be many different types of stakeholders. A relatively basic and clear separation is that applied by Gemünden and Ritter (Gemünden, Ritter et al. 1996), which is schematically shown in Figure 2-3.

The different stakeholders as described by Gemünden et al may have different functions in the R&D process, but in terms of the effects on innovation an even more simplified typology can be sufficient. In line with this, the typology applied in the CIS survey is slightly different and distinguishes between seven types of partners in R&D cooperation:

- Other enterprises within the enterprise group
- Suppliers of equipment, materials, components, or software
- Clients or customers
- Competitors or other enterprises in your sector
- Consultants, commercial labs or private R&D institutes
- Universities or other higher education institutions
- Government or public research institutes

To some extend the typology applied in the CIS survey is a simplified version of the typology applied by Gemünden and Ritter. Also besides simplification there are some fundamental differences between the typologies. These simplifications and differences are discussed below, which with some modifications leads up to the typology applied for the research.

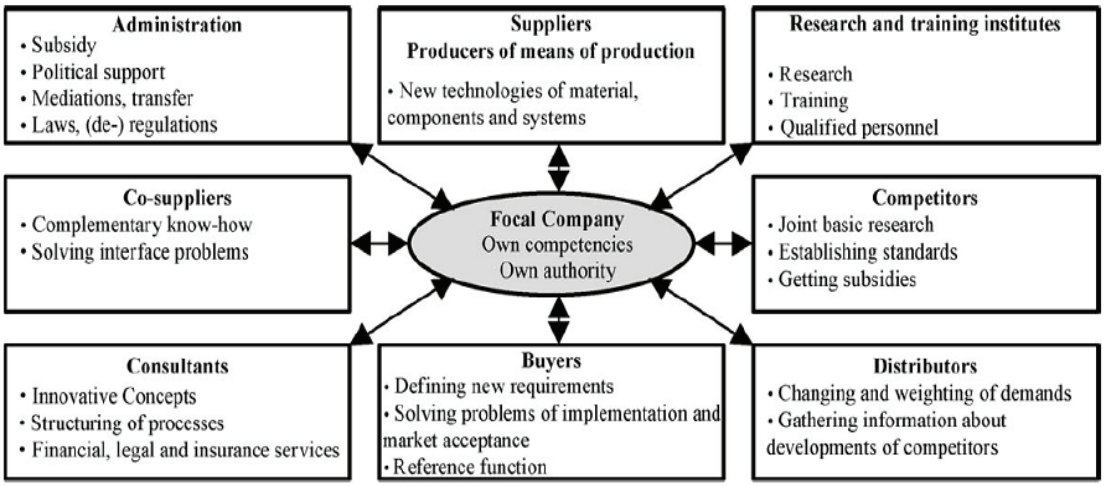

Figure 2-3 Types of innovation stakeholders according to Gemünden and Ritter (Gemünden, Ritter et al. 1996; Ritter and Gemunden 2003)

Where Gemünden and Ritter make a clear distinction between buyers and distributors, the CIS survey only distinguishes customers in general. To some extend the roles of buyers and distributors in the innovation process are similar. Both types of stakeholders are relevant in determining (market) demands and requirements for innovation. However there are also some relevant differences. Although both buyers and distributors provide access to relevant information on the market, buyers are more important in determining function and implementation of innovation in respect to the market acceptance of that innovation. Distributors on the other hand are strongly aware of market developments and thus more important for the market positioning of an innovation. For this research the latter distinction is not highly relevant and therefore the typology applied by the CIS only identifies customers in general.

Secondly, Gemünden and Ritter make a strong distinction between competitors and co-suppliers. Co-suppliers are defined as companies in the same sector that jointly supply a good or service with the organization in question. The CIS survey however identifies competitors and 'other enterprises in the same sector' as a single stakeholder type. Although both stakeholder types possess complementary knowledge and can be important in establishing standards, the CIS typology neglects the important issue that co-suppliers are not (direct) rivals of the focal organization and are often a complement rather than a substitute. Especially from strategic management perspective this is an important, fundamental difference. For this research it will be assumed that the definition of competitor rather than co-supplier applies for this type of stakeholder.

Furthermore, Gemünden and Ritter make a distinction between consultants, administration and research institutes, where the CIS distinguishes between consultants & private research institutes, higher educational institutes and public research institutes. Here, the distinction from the CIS survey is generally more practical. Where educational institutes and (other) public research institutes represent both functions of administration and research institutes. However, the CIS typology lacks a distinction between consultants and private research institutes, which is relevant in the sense that consultants mostly provide operational knowledge and research institutes mostly provide specialized technological knowledge. In the research the emphasis is put on the function of research institutes for this type of stakeholder, called 'private science partners'. Also since the roles of educational institutes and public research institutes in practice are hard to distinguish, the research will treat them as one single type of stakeholder, called 'public science partners'.

Table 2-1 Applied stakeholder typology with the link to the typology by Gemünden and practical examples of the types of organizations as according to the CIS survey

Stakeholder type	Role (Gemünden, Ritter et al. 1996)	Types of organizations (CIS)
Customers	Buyers, distributors	Clients or customers
Suppliers	Suppliers	Suppliers of equipment, materials, components, software
Competitors	Competitors, co-suppliers	Competitors or other organizations in the same sector
Private science partners	Consultants, research institutions	Consultants, commercial labs and private research institutes
Public science partners	Administration	Higher educational institutes (universities), public research institutes, government

Finally, it is also important to notice that the category 'other enterprises within the enterprise group' that is available from the CIS data will not be applied in the typology of the research. This type of partner is only available for a small part of the total sample of organizations, namely those that are part of an enterprise group. Also the function or role of this type of partner is dependent on the type of enterprise in question, which information is not available. Nevertheless, this category is still

relevant in identifying and controlling for multinationals or enterprise groups which could have different mechanism that effect innovation.

This all leads up to the stakeholder typology applied for the research as it is summarized in Table 2-1. Also a visual representation of this typology similar to the representation of Gemünden and Ritter's model of Figure 2-3 is presented in Figure 2-4. The typology identifies five types of partners or stakeholders in the R&D process, namely customers, suppliers, competitors, private science partners and public science partners.

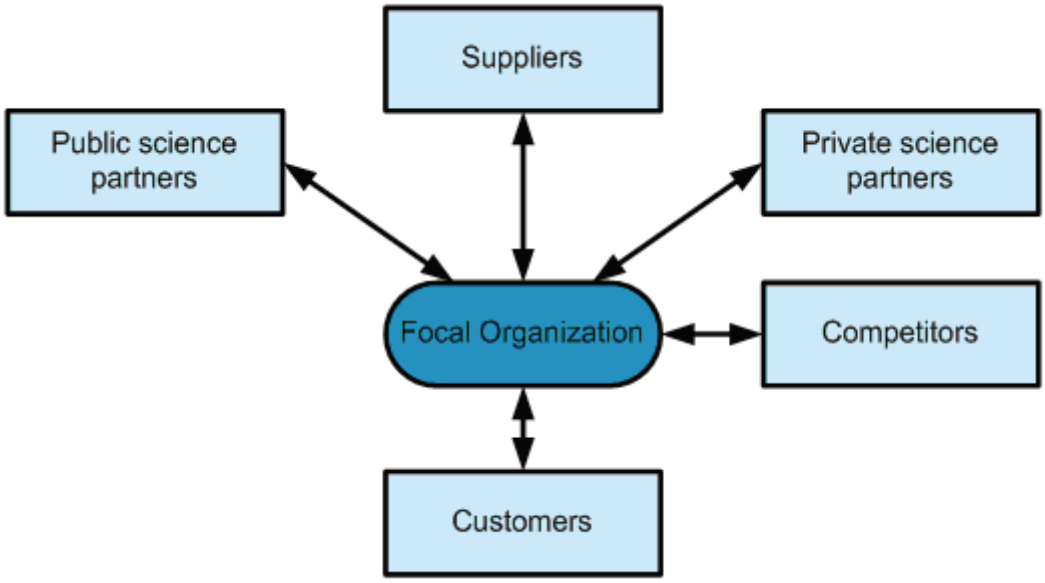

Figure 2-4 Stakeholder typology applied for the research

2.4.2. Geographic location

The geographic location of an organization can logically be categorized in many different ways, of which the most logical are by country, geographic market or continent. In the CIS survey another categorization is applied:

- The home country, in this case The Netherlands
- Other European countries
- United states
- All other countries

This distinction seems oversimplified in the sense that distinctions are made on a very high level and do not account for certain relevant differences between for instance western vs eastern Europe or Japan vs South America etc. Nevertheless a rough distinction between the most relevant markets for Dutch based organizations, namely the home market, Europe and the United States can be expected to be relevant to certain extend. The distinction will be assumed to be strong enough to apply in a very rough measure for the geographic diversity of R&D partners, as will be discussed the following chapters.

2.5. Diversity of cooperation partners

In the previous paragraph several typologies have been discussed for (R&D) cooperation partners in order to be able to link the different types of partners and their characteristics to innovation measures. However the composition of the total spectrum of partners can be interesting as well. This study therefore also examines the effects of the diversity of the total set of partners an organization cooperates with in R&D. Diversity is the property of a group. The definition applied here is that diversity is the presence of a wide variation in relevant attributes between the actors of a certain group.

In social interaction/cooperation it is largely accepted that a diverse set of actors can enhance the breadth of perspective, cognitive resources, creativity and overall problem solving capacity of the group (Cohen and Levinthal 1990; Rodan and Galunic 2004; Goerzen and Beamish 2005). This would mainly be the result of the diverse pool of knowledge that exists between such heterogeneous actors. If we apply the theory of cognitive distance (Nooteboom 2003), it can be argued that within a diverse set of actors, there is some cognitive distance between each of the actors which together create a huge breadth of knowledge. From this cognitive distance, the novelty of ideas will be very high which enhances the creativity and problem solving capacity of the group. However, in line with Nooteboom's perspective, there are also disadvantages to such cognitive distance. The differences in interpretation, values, interests etc. between diverse actors can strongly impede communication and coordination and thus the efficiency of joint efforts (Parkhe 1991; Nooteboom 2003). Diversity of actors therefore is a relevant and complex issue in cooperation. For this study it is assumed that such diversity effects not only exist for individuals, but also

between organizations. In the case of organizations an effect is even added by the fact that organizations also possess important physical resources that can be of importance and of added value in cooperation.

From a network perspective the above mentioned effects of diversity are magnified in the sense that it can be assumed that strongly diverse organizations are also connected to separate and diverse networks. The network an organization is embedded in, is usually a very important source of knowledge. Burt (Burt 2000) argues that when there are structural holes between an organization's (sub)networks, thus that the networks of its partners are not interconnected, these networks contain different flows of knowledge. Therefore the breadth and diversity of knowledge between diverse cooperation partners is not only limited to their individual knowledge, but also to their networks.

Whether organizations are meaningfully different is pertained in the typologies as they were discussed previously in this chapter. From these typologies of stakeholder type and geographic location, measures for meaningful diversity of partners can be extracted. How these types of diversity exactly are meaningful in the context of innovation will be discussed in chapter 4. How the diversity measures will be calculated exactly will be discussed in chapter 6.

3. Conceptualization of innovation

The innovative performance of organizations has been studied intensively over a long period of time. However, the results of these studies have not led to a single generally accepted indicator for innovativeness or innovative performance, but to a variety of constructs (Hollenstein 1996; Garcia and Calantone 2002; Hagedoorn and Cloodt 2003). The constructs and concepts on innovation applied for this particular study will be discussed in this chapter.

3.1. Defining innovation

Many definitions for innovation exist throughout the literature. These definitions and theory of innovation, however, have an identical basis in the pioneering work on innovation by Joseph Schumpeter (Schumpeter 1934). Schumpeter's early definition of innovation is still very present in current conceptualizations of innovation. He defined innovation as "new combinations" of existing resources and identified the following examples or categories:

- The introduction of a new good that is one with which consumers are not yet familiar, or of a new quality of a good.
- The introduction of a new method of production, which need by no means be founded upon a discovery scientifically new, and can also exist in a new way of handling a commodity commercially.
- The opening of a new market that is a market into which the particular branch of manufacture of the country in question has not previously entered, whether or not this market has existed before.
- The conquest of a new source of supply of raw materials or half-manufactured goods, again irrespective of whether this source already exists or whether it has first to be created.
- The carrying out of the new organization of any industry, like the creation of a monopoly position or the breaking up of a monopoly position

Schumpeter also described a clear distinction between an invention and an innovation (Schumpeter 1934). He argued that inventions, when not carried out in

practice, are irrelevant. Therefore entrepreneurship is necessary to see the business opportunities and cope with the difficulties and resistance of introducing an invention to the economic practice (Schumpeter 1934; Schumpeter 1947).

The theory basis by Schumpeter is still apparent in practically all the current definitions for innovation. From these current definitions of innovation, the most complete and universal one is the process definition applied by the OECD (Garcia and Calantone 2002):

> *'Innovation' is an iterative process initiated by the perception of a new market and/or new service opportunity for a technology based invention which leads to development, production, and marketing tasks striving for the commercial success of the invention.'*

In line with Schumpeter this definition addresses an important distinction, namely that the innovation process not only comprises the (technological) development of an invention, but also the market introduction of that invention to customers (Garcia and Calantone 2002). This distinction is very relevant in the context of innovation and cooperation as will be discussed in the next paragraph.

3.2. Exploration vs. exploitation

The theory and definitions in the previous paragraph highlight the importance of a distinction between the development of an invention and the commercialization of that invention. Where the development of an invention is a creative process that is concerned with acquiring new knowledge and ideas, the commercialization of that invention is concerned with applying the acquired knowledge and other existing knowledge in order to effectively and efficiently bring the invention to the market. This is strongly related to the dichotomy of exploration and exploitation that is often applied in literature on organizational learning (March 1991; Koza and Lewin 1998; Rothaermel 2001). Here, exploration is to explore new possibilities and obtain or create new capabilities and knowledge. Exploitation is to exploit existing capabilities and enhance them. As such exploration refers to notions of search, variation, experimentation, flexibility and discovery. Exploitation more refers to notions of

improvement, refinement, efficiency, selection and execution (March 1991; Koza and Lewin 1998; Rothaermel and Deeds 2004). In the context of innovation it can be argued that exploration is mainly important for the technological development of an innovation and exploitation is mainly important for creating economic value from that innovation.

3.2.1. Exploration and exploitation in cooperation

The distinction between exploration and exploitation in organizational learning is important for the context of inter-organizational cooperation. From a strategic perspective, inter-organizational relationships can be distinguished in terms of their motivation to be explorative or exploitative (Koza and Lewin 1998; Rothaermel 2001). In this, explorative cooperation is mainly focused on creating and improving competencies through the pursuit of knowledge. This is strongly related to upstream activities in the value chain, like basic research. Exploitative cooperation on the other hand is focused on complementarities and synergies of existing competencies. This is strongly related to downstream activities in the value chain, like marketing and sales (Rothaermel and Deeds 2004; Faems, Van Looy et al. 2005).

As such, in the context of innovation it can be argued that a focus on explorative or exploitative cooperation is to a large extend phase dependent (Rothaermel and Deeds 2004). In the early stages of the innovation process an organization usually undertakes R&D cooperation in order to discover something new. Following this successful exploration, the organization turns to cooperation to exploit this new knowledge (Rothaermel and Deeds 2004). Based upon this argumentation Rothaermel (2004) proposes an integrated product development path where an organization's exploration alliances predict its products in development, while an organization's products in development predict its exploitation alliances, and where its exploitation alliances in turn lead to products on the market. This is schematically portrayed in Figure 3-1.

In addition to the above discussion on exploration and exploitation in cooperation, I propose a simplification based on the KBV. In the context of innovation relevant knowledge can roughly be separated into two categories: market oriented knowledge and technological knowledge (Hirshleifer 1973). This separation becomes relevant

when analyzing and applying the theory of exploration and exploitation from a knowledge based perspective. From this simplified view of knowledge I argue that exploration for innovation is mainly focused on extending technological knowledge in the field of innovation in order to obtain the necessary competence for creating innovation (Faems, Van Looy et al. 2005; Phelps 2005). On the other hand I argue that the exploitation of an innovation is mainly focused on extending market orientated knowledge in order to commercialize the innovation and get insight on how to create value from (new) competencies and products (Ottum and Moore 1997; Li and Calantone 1998). Based on these assumptions I can additionally argue that in the context of innovation explorative cooperation is mainly aimed on acquiring technological knowledge, whilst exploitative cooperation is mainly aimed at accessing market oriented knowledge.

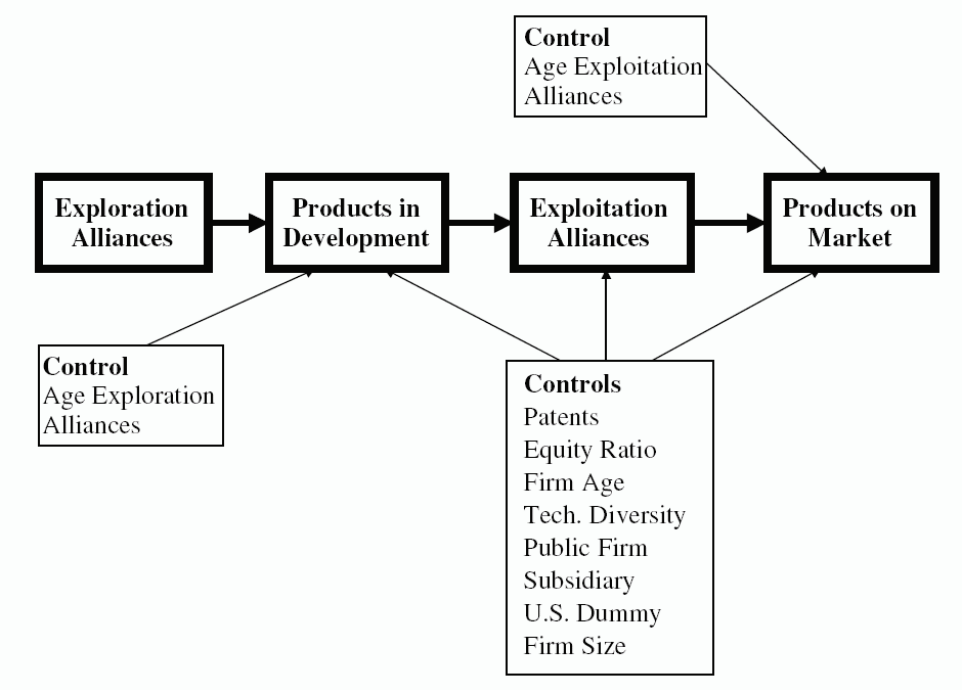

Figure 3-1 Rothaermel's product development path based on alliances (Rothaermel and Deeds 2004)

3.2.2. Innovation intensity vs. innovation success

From the exploration and exploitation perspective it was argued that cooperation types and objectives in an innovation context are path dependent. This suggests that for different phases in the innovation process, different types of cooperation are

important. This is an important notion in deciding how to measure innovation characteristics for an organization. Traditionally, research on innovation is interested on the overall innovation performance or so called innovativeness of organizations for which many different measurement methodologies exist (Garcia and Calantone 2002). However, the literature on innovation measurement has identified significant differences between input measures for innovation, like R&D expenditure, and output measures for innovation, like sales of innovative products (Acs and Audretsch 1988; Kleinknecht, van Montfort et al. 2002). I argue that is a logical result of the fact that the general concept of innovative performance or innovativeness neglects an important separation between an organization's attempts to create innovation and the ability to bring innovation to the market. As such input and output measures for innovation do not portray the same aspects of innovation.

I argue that input measures of innovation portray the amount of initiative and effort in innovation that is undertaken by an organization. When an organization is intensively engaged in a lot of innovation activity, this organization will logically need a lot of input in innovation, like investment, employees, etc. This effort or engagement in innovation is called the 'innovation intensity' of an organization, which is a fairly established term in innovation literature and is actually officially classified by the OECD (OECD 2005).

Output measures of innovation on the other hand, besides innovation activity, also largely portray the commercial success an organization actually derives from innovation. When an organization is very successful in creating relevant innovation and bringing it to the market, this company will have a lot of innovative output, like innovative products and sales of new products. This success in creating and commercializing innovation, I call the 'innovation success' of an organization and is a fairly novel construct in innovation measurement as will be explained in chapter 6. Important to note here is that innovation success, as mentioned, does not solely determine the innovative output of an organization. Innovation intensity logically also plays a big role.

Logically, the aspects of innovation intensity and innovation success together portray the overall innovation performance or innovativeness of an organization. The notions that input and output measures of innovation indicate significantly different aspects of innovation and that cooperation is path dependent in the context of innovation, suggest a that multidimensional approach is necessary for measuring

innovation for this research. I propose to measure innovation by determining separate measures for relevant dimensions of innovation, of which innovation intensity and innovation success are the two most important. By applying these innovation indicators separately to determine the relations between cooperation and innovation, the effects of cooperation on innovation can be made more explicit and specific in respect to applying a single, general notion for innovation performance. The precise measurement for this will be discussed in chapter 6.

3.3. Innovation typology

In order to determine the scope and (additional) dimensions of innovation as they will be applied in this research, it is necessary to discuss several relevant typologies of innovation. Current literature applies many different typologies for innovation, of which the most reoccurring are the following:

- Product vs. process innovation (Utterback and Abernathy 1975; Tidd, Bessant et al. 2005)
- Technological vs. administrative innovation (Daft 1978; Cooper 1998)
- Incremental vs. radical innovation (Ettlie, Bridges et al. 1984; Dewar and Dutton 1986; Garcia and Calantone 2002)
- Continuous vs. discontinuous innovation (Veryzer 1998)
- Architectural vs. modular/component innovation (Henderson and Clark 1990)
- Complex vs. simple innovation (Hobday 1998)

The above typologies however are often very similar or highly interrelated. Additionally, there seems to be some consensus in the literature on which distinctions are the most relevant. These relevant typologies are also present in the CIS survey data and have an important role in the research. Therefore they have to be discussed.

One typology that is found often in the literature is the distinction between product and process innovation (Utterback and Abernathy 1975; Tidd, Bessant et al. 2005), often extended with a classification of organizational innovation (Boer and During 2001).

Another main typology that is often applied in the literature is that of incremental and radical innovation (Ettlie, Bridges et al. 1984; Dewar and Dutton 1986). Note that

this typology is very similar to the distinction between continuous and discontinuous innovation and is highly interrelated with the typologies of architectural and modular innovation and complex and simple innovation (Garcia and Calantone 2002).

These two typologies and their relevance for the research will be explained in the two paragraphs to come.

3.3.1. Product, process and organizational innovation

In the early definition of innovation Schumpeter (1934) already distinguished between the introduction of new good, new method, new market, new source and new organization as was discussed in an earlier paragraph. Later, the notion came that most of these types of innovation are fundamentally different in terms of targets, approaches and effects. A dominant distinction here is that between product and process innovation (Utterback and Abernathy 1975). In this distinction a product innovation reflects change in a product or service to meet a user or market need. Process innovation represent changes in the way products or services are produced (Utterback and Abernathy 1975; Cooper 1998). This however does not entail the complete spectrum of innovation categories. Other relevant categories defined in the literature are organizational or paradigm innovation (Damanpour 1991; Tidd, Bessant et al. 2005) and marketing or position innovation (Tidd, Bessant et al. 2005). Here organizational or paradigm innovation reflects changes in the underlying mental modes and structures framing what an organization does (Tidd, Bessant et al. 2005). Marketing or position innovation represents changes in the context and methods products or services are introduced to the market (Tidd, Bessant et al. 2005).

The CIS survey makes a similar distinction between product innovation, process innovation, organizational innovation and marketing innovation. When discussing innovation the literature generally refers to product innovation, especially in the context of cooperation and innovation. On the relation between cooperation and process, organizational or marketing innovation there is not much literature available. This and the fact that most numerical data in the CIS survey is related to product innovation, has resulted in a focus on product innovation for this study. Therefore, in the remainder of this paper the term innovation refers to product innovation in particular.

3.3.2. Radical vs. incremental innovation

In the literature an important dimension of innovation is the degree of novelty of the innovation. However, definitions for the degree of novelty are numerous and dependent on the perspectives applied (Garcia and Calantone 2002). Usually the literature distinguishes between radical and incremental innovation (Ettlie, Bridges et al. 1984; Dewar and Dutton 1986; Garcia and Calantone 2002). In the early definitions of radical and incremental innovation, there was a focus on changes in the activities of an organization. In these definitions radical is when the innovation produces fundamental changes in the activities of an organization and represents a departure of existing practices. Incremental innovation on the other hand results in little to no departure of existing practices (Ettlie, Bridges et al. 1984; Dewar and Dutton 1986). In the specific case of product innovation the degree of radicalness is usually defined by how radical, unique and/or competitive the changes are to a product (Cooper 1979; Kleinschmidt and Cooper 1991). The two main determinants for this are the newness to the market (Cooper 1979; Cooper and Kleinschmidt 1987; Kleinschmidt and Cooper 1991; Atuahene-Gima 1996; Johannessen, Olsen et al. 2001; Tidd, Bessant et al. 2005) and the technological change of the product (Green, Gavin et al. 1995; Goldenberg, Lehmann et al. 2001; Gatignon, Tushman et al. 2002). The CIS survey has adopted a measure based on the newness to the market by distinguishing between products 'new to the firm' and 'new to the market'. This taxonomy neglects the technological aspect of the novelty of innovation and as such does not completely represent the broad definition of innovation novelty. Due to the lack of an available measure for the technological aspect this study will therefore base its notion of innovation novelty solely on the market novelty of innovation. There will be more elaboration on this and the concrete measurement in chapter 6. It is important to note that in the literature review and theoretical models the concept of innovation novelty is introduced in its broad sense, including the technological aspect. However, due to the described data limitation, the empirical analysis of the effects on innovation novelty is solely based on a measure of market novelty of innovation.

The concept of innovation novelty is relevant in the context of this study for several reasons. The most obvious reason is the difference in risks and results for incremental and radical innovation. In general a high degree of novelty of an

innovation is associated with high risk, but also with more profound effects and higher results (Kleinschmidt and Cooper 1991; Gatignon, Tushman et al. 2002).

Another issue is that the degree of novelty of an innovation is strongly determined in whether there is a focus on the market or on technology, as can be learned from the theory on (market)demand-pull and technology-push mechanisms in creating innovation (Dosi 1982). Here, a focus on technology is expected to lead to completely new, radically innovative products, whereas a focus on the market is expected to lead to adaptations of existing products and thus incremental innovation. In the context of cooperation this means that explorative cooperation, which was argued to be aimed at acquiring technological knowledge, can be expected to lead to radical innovation. Exploitative cooperation on the other hand with a focus on market oriented knowledge is more likely to lead to incremental innovation (Faems, Van Looy et al. 2005).

Finally, from the cognitive theory by Nooteboom as discussed in paragraph 2.3.4 we have learned that the larger the cognitive distance between cooperating parties, the more novel the solution will be. This implies that the more unique and diverse the knowledge is that is shared between two cooperating parties, the more novel the solution, or in this case innovation, is expected to be.

In the context of this research which focusses at the innovative characteristics of organizations, the novelty of specific products is not directly of interest, but the tendency and ability of an organization to produce such novel innovation is. Therefore when addressing the innovation novelty of an organization in this study, it is this ability or tendency to produce novel innovation that is meant.

4. Inter-organizational cooperation and innovation

Many studies have researched the relation between cooperation and innovation. In this chapter the main findings from the literature will be discussed in the context as it has been set in the previous chapters.

4.1. R&D Cooperation and innovation in general

Cooperation has already become an important aspect in innovation and this importance only seems to be increasing. With innovation pressure and product complexity increasing, practically all innovations demand some form of cooperation, either in development or commercialization (Tidd, Bessant et al. 2005). In line with this Rothwell (1994) imposed a big role on cooperation in his description of the fourth and fifth generation innovation process. He described the key aspects for the 5G innovation process as being: integration, flexibility, networking and parallel information processing. Also he described the main benefits for the 5G process as coming from the handling of information across the whole system of innovation, including suppliers, customers and collaborators, i.e. (Rothwell 1994).

Thus, cooperation is generally accepted to be important for innovation, but why is this? What are the main motives for cooperating in innovation? Aggregating the results for several studies analyzing organizations' motives to cooperate provides the following list of possible reasons to cooperate in innovation (Hagedoorn 1993; Pittaway, Robertson et al. 2004; Tidd, Bessant et al. 2005):

- Risk/cost sharing in technological development or market entry
- Access to markets and technologies
- Diffusion of innovations across and within sectors
- Pooling complementary skills
- Obtaining access to external knowledge and shared learning
- Reduce time (speed) to develop or commercialize new products/services
- Monitoring for environmental changes and opportunities
- Safeguarding property rights

This list, not even being exhaustive, shows that in theory there are many reasons for organizations to cooperate in innovation. However, logically there are also disadvantages or risks involved in cooperating on innovation activities. The main potential risks that have been identified in several studies are (Littler, Leverick et al. 1995; Tidd, Bessant et al. 2005):

- Leakage of sensitive information
- Loss of control or ownership
- High costs of coordinating the cooperation
- Conflict resulting from divergent aims and objectives

Although the benefits seem to outweigh these risks, in practice the failure rates of (R&D) cooperation initiatives are very high (Ireland, Hitt et al. 2002; Rothaermel and Deeds 2006). This has provided incentive for better understanding and empirical investigation of specific effects of cooperation on innovation and business performance in general. Studies on this subject in most cases support the general notion of cooperation facilitating innovation (Shan, Walker et al. 1994; Baum, Calabrese et al. 2000; Harabi 2000; Stuart 2000; Faems, Van Looy et al. 2005; Phelps 2005), but there have been contradictory results as well (Freel 2003). Some studies also suggest that the relationship between cooperation and innovation is more complex and involves many factors (Love and Roper 2001; Henttonen 2006). An overview of several studies and their main findings on the general relation between cooperation and innovation is presented in Appendix A. The mixed results suggest that cooperation does not always have a positive effect on innovation, and thus that different forms of cooperation have separate effects (for innovation). Therefore the focus of research in the field has been directed towards examining the specific effects of certain types of cooperation on innovation. This study follows that line with a focus on partner characteristics in R&D cooperation and their specific effects on innovation.

4.2. Theory on partner types and innovation

As was discussed in chapter 2.4, a distinction is made between partners based on their role in the value chain, or in other words the type of stakeholder. In the context of cooperation this distinction is often applied and thus there is a considerable amount of literature surrounding this typology. This paragraph discusses, per partner type, the

main results and theories from previous studies relevant in the context of innovation. A complete overview of the main articles that were studied and their main findings is provided in Appendix A.

An important note here is that in the literature the categorization on type of cooperation partner is somewhat divergent. In the literature the basic distinction between vertical and horizontal cooperation is often applied (Jorde and Teece 1990; Inkmann 2000; Atallah 2002; Cassiman and Veugelers 2002; Miotti and Sachwald 2003; Faems, Van Looy et al. 2005). Where horizontal cooperation comprises cooperation with competitors or other organizations in the same sector, it is similar to what I define as competitor cooperation. Vertical cooperation however, comprises cooperation with both customers and suppliers and thus combines the two categorizations of customer cooperation and supplier cooperation, which I argue to have separate effects.

4.2.1. The role of customers

Many studies link vertical cooperation in general to superior commercial success of new product development (Gemünden, Ritter et al. 1996; Miotti and Sachwald 2003). Vertical cooperation is argued to be important mainly due to the high synergy between the cooperation parties (Gemünden, Ritter et al. 1996; Miotti and Sachwald 2003) and the access to market information (Miotti and Sachwald 2003). Especially market information seems to be related to customer cooperation in particular (Belderbos, Carree et al. 2004; Pittaway, Robertson et al. 2004; Belderbos, Carree et al. 2006). One of the first to recognize the importance of customers in the innovation process was Von Hippel (von Hippel 1978) who argued that customers should play an active role in the innovation process since they are capable of identifying ideas for development. Customers are considered to be of great importance in identifying user needs, market opportunities and targeting innovation correctly (Pittaway, Robertson et al. 2004). Therefore customer involvement should lead to higher acceptance and diffusion of products on the market and thus to increased commercial success. This relation between customer cooperation and increased innovation success has been identified in several empirical studies (Gemünden, Ritter et al. 1996; Cassiman and Veugelers 2002; Faems, Van Looy et al. 2005; Belderbos, Carree et al. 2006).

However, there is no clear evidence that customer involvement has a positive effect on innovation performance in general (Romijn and Albu 2002; Knudsen 2007). This is most likely caused by the fact that customers do not constitute a coherent set of needs and preferences (Knudsen 2007) leading to difficulty in generating concrete and feasible ideas from such ambiguous needs and preferences. Therefore the process of customer cooperation in innovation can be inefficient even though there often is synergy and cooperation experience between the parties.

Another issue in customer cooperation and innovation is that customer involvement is usually considered highly important in incremental innovation (Veryzer 1998; Pittaway, Robertson et al. 2004). Customers often have aadversity to change and are argued to have a limited mindset about an existing product. Therefore ideas and suggestions are usually based on existing products and change is preferably minimized since customers have grown accustomed or dependent to the existing product.

In summary, customer cooperation is important for innovation. Customer involvement provides access to market needs and opportunities and as such is crucial in the promotion and diffusion of innovation. Also customer cooperation is in general associated with incremental innovation.

4.2.2. The role of suppliers

As was stated in the previous paragraph vertical cooperation in general is linked to superior commercial success of new product development (Gemünden, Ritter et al. 1996; Miotti and Sachwald 2003). Where for customer cooperation it was discussed that the emphasis was on market information, supplier cooperation entails more factors relevant for the innovation process. Like with customer cooperation, suppliers do provide access to specific market information and opportunities, since they are well embedded into the market and are aware of movement from the competition (Miotti and Sachwald 2003). However, the higher level skills and knowledge on component level from suppliers are also highly important in the innovation process. This more technological oriented knowledge is important in the development of innovation and identifying technological opportunities (Romijn and Albaladejo 2002; Romijn and Albu 2002; Pittaway, Robertson et al. 2004; Knudsen 2007). Furthermore, the high synergy between the parties and complementary knowledge

also increase the productivity and efficiency of the innovation process (Belderbos, Carree et al. 2004). Therefore supplier cooperation is considered to have a positive effect on both the intensity and the commercial success of innovation and thus innovation performance in general. This relation has also been tested and proven in several empirical studies (Romijn and Albu 2002; Faems, Van Looy et al. 2005; Knudsen 2007).

In summary, supplier cooperation is considered to provide access to both market and technological knowledge crucial for the innovation process. As such, supplier cooperation is generally associated with high innovation performance, both commercially and operational.

4.2.3. The role of competitors

Cooperating with competitors is often a subject of public discussion, especially when it seems to conflict with public interests like in cases of price collusion. Nevertheless research on horizontal or competitor cooperation is limited and such cooperation only rarely takes place in practice (Inkmann 2000; Miotti and Sachwald 2003). There seem to be many benefits to competitor cooperation in innovation. Sharing resources and costs with competitors clearly reduces risks for all parties and their position in the market (Baumol 1992; Harabi 2002). Also cooperation between competitors omits wasteful duplication and assists in setting technological standards and bringing products (quickly) to the market (Jorde and Teece 1990; Baumol 1992; Harabi 2002). Competitors each have their channels to bring innovation to the market and can have access to different (geographical) markets, thus cooperation should be beneficial for diffusing innovation. Finally, competitors have highly specialized and often unique knowledge in the same technological field and thus should be strongly compatible for cooperation.

Nevertheless this form of cooperation is largely hampered by the potential risks and lack of trust. As was discussed earlier, one of the main risks of cooperation is the leakage of sensitive information. Especially in cooperation between competitors this becomes an important issue (Cassiman and Veugelers 2002). Protection measures and an overall distrust of competitors can strongly hamper the efficiency of the cooperation.

The disadvantages and risks of cooperation with competitors and the familiarity with suppliers and customers usually lead to a preference for cooperating with these latter parties rather than with competitors. Nevertheless the advantages seem to outweigh most of the disadvantages and several studies have identified a positive effect of competitor cooperation on innovation (Jorde and Teece 1990; Belderbos, Carree et al. 2004). Especially the commercial success seems to be positively influenced by cooperating with competitors (Belderbos, Carree et al. 2004), which is in line with the mentioned benefits of setting standards and bringing innovation to the market. Also competitor cooperation has been found to mainly be important for creating and bringing to market of radical innovations (Belderbos, Carree et al. 2004), which can be explained by the specific technological knowledge competitors have in their field.

A possible adverse effect of competitor cooperation is the fact that due to the extensive cooperation between competitors the level of competition in the market drops, thus reducing the incentive to innovate (Baumol 1992). Therefore it can be expected that competitor cooperation has a negative effect on innovation intensity.

In summary, competitor cooperation can be very fruitful for innovation. The complementary technological knowledge and access to markets will be beneficial in creating and bringing to the market radical innovation. However, with competitor cooperation there is a large chance of friction hampering the efficiency of cooperation efforts. Also the competitive incentive to innovate is reduced which might lead to a negative effect on innovation intensity.

4.2.4. The role of science partners

Where science logically often plays a role in (technological) innovation, science partners can be an important source of knowledge. In this research the term science partners refers to research institutes, consultants, higher educational institutions etc. Science partners possess highly specialized and unique (technological) knowledge and therefore can be an important cooperation partner. Science partner cooperation provides access to this specialized knowledge, and as such is considered to have a positive effect on innovation performance (Cassiman and Veugelers 2002; Pittaway, Robertson et al. 2004). This effect has been tested and proven in several empirical studies (Cassiman and Veugelers 2002; Miotti and Sachwald 2003; Belderbos, Carree

et al. 2004; Faems, Van Looy et al. 2005). Also several studies have found that science partner cooperation tends to be most important for radical innovation (Kaufmann and Todtling 2001; Belderbos, Carree et al. 2004; Ebersberger, Laursen et al. 2005). This logically follows from the unique and high level nature of the knowledge that science partners possess.

Difference between private and public science partners

The above discussion on science cooperation does not make a distinction between public and private science partners, as does most of the literature. However, in the context of innovation this distinction is indeed relevant. Public science partners here comprise higher educational institutions or other public research institutions, whilst private science partners comprise consultants, commercial labs and private research institutes. Public science partners are argued to have some additional effects on innovation as the ones mentioned above. They are argued to have an important role in promoting new innovation and thus for the commercial success of an innovation (Cooke and Wills 1999; Pittaway, Robertson et al. 2004). This is related to their important position in and regulation of the cooperation networks through rules and subsidies (Etzkowitz and Leydesdorff 2000; Cassiman and Veugelers 2002; Mohnen and Hoareau 2003; Pittaway, Robertson et al. 2004).

However, public science partner cooperation can also be argued to have disadvantages. Where public institutions usually have different goals and motives compared to commercial or private institutions, it is likely that there will be some friction from this in the cooperation process. Also with public science partners being linked to the strict governmental structure and objectives there can be a big loss of control over the innovation process for the focal organization when cooperating with such partners. Private science partners on the other hand are usually driven by similar motives as a commercial organization, which omits this friction.

In summary, science partner cooperation in general should have a positive effect on innovation performance, especially in developing radical innovation. In this, public science partners can have an additional effect in the promotion or diffusion of innovation to the market.

4.3. Theory on partner diversity and innovation

As was discussed in chapter 2, diversity of cooperation partners can have relevant effects on the cooperation process and output. From the theory of cognitive distance by Nooteboom (Nooteboom 2003), it was explained that with larger cognitive distance or breadth of knowledge between multiple cooperation partners comes a higher creativity or novelty of ideas, accompanied however with a reduction of the efficiency of the cooperation. In the context of innovation, from this it can be argued that a diverse set of cooperation partners will lead to a more creative and thus radical innovation process. Also the increased breadth of knowledge will provide not only more creative ideas, but also more ideas in general which can be argued to intensify an organization's activities in innovation. However, a diverse set of cooperation partners will impede the efficiency of the cooperation and thus of the innovation process, which would hamper the operational or commercial success of the innovation process. The latter effect is also in line with the transaction cost perspective, from which would be argued that maintaining many, completely different relations is associated with high risk and cost.

In several recent studies these effects of diversity of partners and/or knowledge on the innovation process have extensively been tested. Most studies find a positive relation between diversity and general notion of innovation performance (Feldman and Audretsch 1999; Baum, Calabrese et al. 2000; Kaufmann and Todtling 2001; Rodan and Galunic 2004; Henttonen 2006; Yao and McEvily 2007). More specifically, diversity has been linked to innovation intensity in particular (Ruef 2002; Phelps 2005; Laursen and Salter 2006). Also the effect on the novelty of innovation has been investigated by some studies, which concluded that indeed diversity leads to radical innovation or vice versa that a lack of diversity blocks radical innovation (Nooteboom 2000; Knudsen 2007).

However, not all studies find a straightforward positive relation between diversity and (innovation) performance. Often the relation more resembles an inverted U-shape, where there is an optimum level of diversity after which innovation performance starts dropping (Laursen and Salter 2006; Yao and McEvily 2007). This can be explained by the previously explained detrimental effects of diversity in cooperation on efficiency and costs and the fact that the benefits of diversity start to diminish at a certain point. Once diversity or breadth of knowledge is already high, the added value

of new diverse knowledge becomes less and the chance that new knowledge is truly diverse becomes less. Thus while the benefits of diversity are diminishing, the costs are increasing, creating a tipping point after which diversity negatively effects innovation performance (Goerzen and Beamish 2005; Laursen and Salter 2006). This is in line with the theory of cognitive distance which predicts an optimal cognitive distance on which performance is highest (Nooteboom 2003).

In summary, meaningful diversity of cooperation partners is expected to have a positive effect on the intensity of the innovation process of an organization and the novelty of innovations created. However the benefits of diversity have diminishing returns on scale and increasing disadvantages in inefficiency and costs of maintaining cooperation.

4.3.1. Meaningful diversity

As was explained previously, diversity only matters when it is meaningful and can have an effect on the innovation. In chapter 2 it was argued that two types of meaningful diversity can be derived from the typologies applied for stakeholder type and geographic location of partners. How these types of diversity are relevant in the context of innovation will be explained here.

Stakeholder diversity

Stakeholder diversity can be relevant for several reasons, many of which have become apparent in discussing the roles of the different types of stakeholders. First off, there is the fact that different stakeholders, especially stakeholders connected in a value system, can have complementary knowledge and resources, where similar type stakeholders can be assumed to have similar, substitutive knowledge and resources (Belderbos, Carree et al. 2006). They possess specific (technological) knowledge for their position in the value system and on separate (component) levels. A combination of different types of stakeholders and their specific knowledge and resources in this sense should be broader and more valuable than a combination of similar stakeholders with highly similar knowledge.

Also the different types of stakeholder have different positions in the market and therefore different perspectives on the market. This means that different types of

stakeholders can be expected to have different knowledge market needs and opportunities. Also it is likely that there is a difference in their surrounding networks and mechanisms to reach the market.

The relevance of stakeholder diversity has been argued and proven in several studies (Gemünden, Ritter et al. 1996; Pittaway, Robertson et al. 2004; Belderbos, Carree et al. 2006; Knudsen 2007). Stakeholder diversity seems to have a relevant effect on knowledge diversity for innovation as expected.

Geographic diversity

Besides stakeholder diversity, diversity of geographic location of partners is also argued to be meaningful. One of the reasons for this is the cultural diversity between geographic diverse organizations. Different cultures adopt different approaches and perspectives in problem solving, which could add to the creativity of the innovation process, although this has not been proven (GomezMejia and Palich 1997; Palich and Gomez-Mejia 1999). Another more evident reason is the fact that geographically diverse organizations are embedded in separate national networks of innovation and have access to nation specific resources (Miotti and Sachwald 2003). Therefore a combination of geographically diverse organizations is likely posses a broader spectrum of knowledge and resources than a combination geographical similar organizations.

This positive effect of geographic diversity of partners seems to conflict with the main theories on the regional boundaries and clustering of innovation (Feldman and Florida 1994) and the positive learning effects of proximity (Boschma 2005). However, a positive relation between geographical diversity and the breadth or creativity of available knowledge from cooperation does not oppose these theories, it is actually supported by them. When innovation is geographically localized (in clusters) where extensive learning takes place, it can be argued that a high level of specialization and lock-in is developed in these regions (Boschma 2005). Geographic diversity of partners enables an organization to tap into multiple of such innovation clusters and thus develop a broader spectrum of knowledge outside its own specialization. This also partly explains the expected adverse effects of geographic diversity on the efficiency of cooperation by arguing that different geographical clusters have different specializations and thus have a large cognitive distance and

(other) barriers for cooperation. Moreover, it can be argued that geographic clustering or proximity of organizations has a positive effect on those organizations' tendency to cooperate with each other. It can therefore be argued that the positive learning effects from proximity are not direct or first order, but indirect through this higher cooperation density which is in line with the theory that is applied here.

The relevance of geographic diversity has been argued and proven in several studies (Zahra, Ireland et al. 2000; Romijn and Albaladejo 2002; Freel 2003; Ebersberger, Laursen et al. 2005). Geographic diversity can thus be argued to have a relevant effect on knowledge diversity for innovation.

4.4. Absorptive capacity

As was briefly mentioned in chapter 2, another important issue in cooperation and innovation is the absorptive capacity of an organization. The concept of absorptive capacity was first introduced by Cohen and Levinthal (Cohen and Levinthal 1990), who argued that the ability to evaluate and utilize outside knowledge is largely a function of prior knowledge acquired. They describe this ability as being the absorptive capacity of an organization. In the context of cooperation however a better and more accurate description of absorptive capacity is from a cognitive perspective: Absorptive capacity entails the ability to empathize, i.e. the generalized, non-relation-specific ability to access the thinking of others without thinking alike (Nooteboom 2003).

Although absorptive capacity can not directly be measured empirically, Cohen and Levinthal propose that ongoing R&D activity of an organization is an indicator for the organization's absorptive capacity. They argued that since technological change in an industry is closely related to ongoing R&D activity, an organization's ability to exploit external knowledge is a byproduct of its (internal) R&D activity.

In the context of cooperation, however, I argue that an organization's cooperating skills, might also play an important a role in the ability to exploit external knowledge. The ability to utilize external knowledge from cooperation is not only determined in an organization's ability to understand and apply that external knowledge, but also in the ability to effectively communicate and cooperate with the (external) source of knowledge. I argue that this 'cooperative capability' is generated through prior involvement in (R&D) cooperation. By continuously being involved in cooperation

agreements with other organizations, skills and best practices are developed in dealing with cooperation partners.

Overall in the context of cooperation, absorptive capacity is expected to enable an organization to better understand and apply knowledge that is accessed through cooperation. As such I argue that absorptive capacity is expected to intensify the knowledge effects from cooperation on innovation.

5. Conceptual framework and hypotheses

In this chapter the literature as it has been discussed previously will be attempted to be simplified in a relevant theoretical model. From the literature and the model then the main research hypotheses will be drawn and a conceptual model representing these hypotheses.

5.1. Knowledge based theoretical framework

As was discussed in chapter 2, the dominant perspectives that are applied in investigating the relation between cooperation and innovation are knowledge based and cognitive (learning) perspectives. To obtain a theoretical model on cooperation and innovation solely based on knowledge therefore the effects of cooperation will be simplified to the effects in terms of knowledge.

As was discussed in chapter 3, the relevant knowledge for innovation can roughly be separated into two categories: market oriented knowledge and technological knowledge (Hirshleifer 1973). These separate types of knowledge also can be argued to have separate effects on innovation. Market oriented knowledge is considered to mainly have a positive effect on the commercial success of product innovation (Ottum and Moore 1997; Li and Calantone 1998). Technological knowledge on the other hand is more related to the exploration of an innovation and therefore the intensity on innovation activities (Faems, Van Looy et al. 2005; Phelps 2005). Furthermore from the demand-pull technology-push debate (Dosi 1982) we have learned that market orientation will generally lead to incremental innovation whereas technology orientation will generally lead to radical innovation.

The type of knowledge however is not the only relevant dimension of knowledge. As was discussed in the previous chapters, the breadth or diversity of knowledge is also important. It was argued that diverse knowledge will lead to creativity and thus more initiative or intensity of innovation and to more radical innovation. On the other hand it was found that applying diverse knowledge brings difficulties and can lead to inefficiencies and increased costs in cooperation, which is expected to have a negative effect on an organization's ability to turn innovations into commercial success.

From the literature and theory in the previous chapter, the different types of cooperation can be linked to these dimensions of knowledge. Customer cooperation was found to mainly be related to market oriented knowledge. Supplier cooperation

was tied to both technological and market oriented knowledge, as was competitor cooperation. Science partners have been argued to mainly provide technological knowledge. Besides technological knowledge, public science partners also provide some market orientated knowledge, unlike private science partners. Finally, meaningful partner diversity, like stakeholder diversity and geographic diversity, has been linked to the breadth and diversity of available knowledge.

Additionally, also important is an organization's ability to effectively extract and utilize the knowledge that comes available through cooperation. This absorptive capacity is argued to moderate the relation between cooperation efforts and actually acquiring and being able to apply the knowledge that becomes accessible from that cooperation.

The complete model that follows from all this is depicted in Figure 5-1.

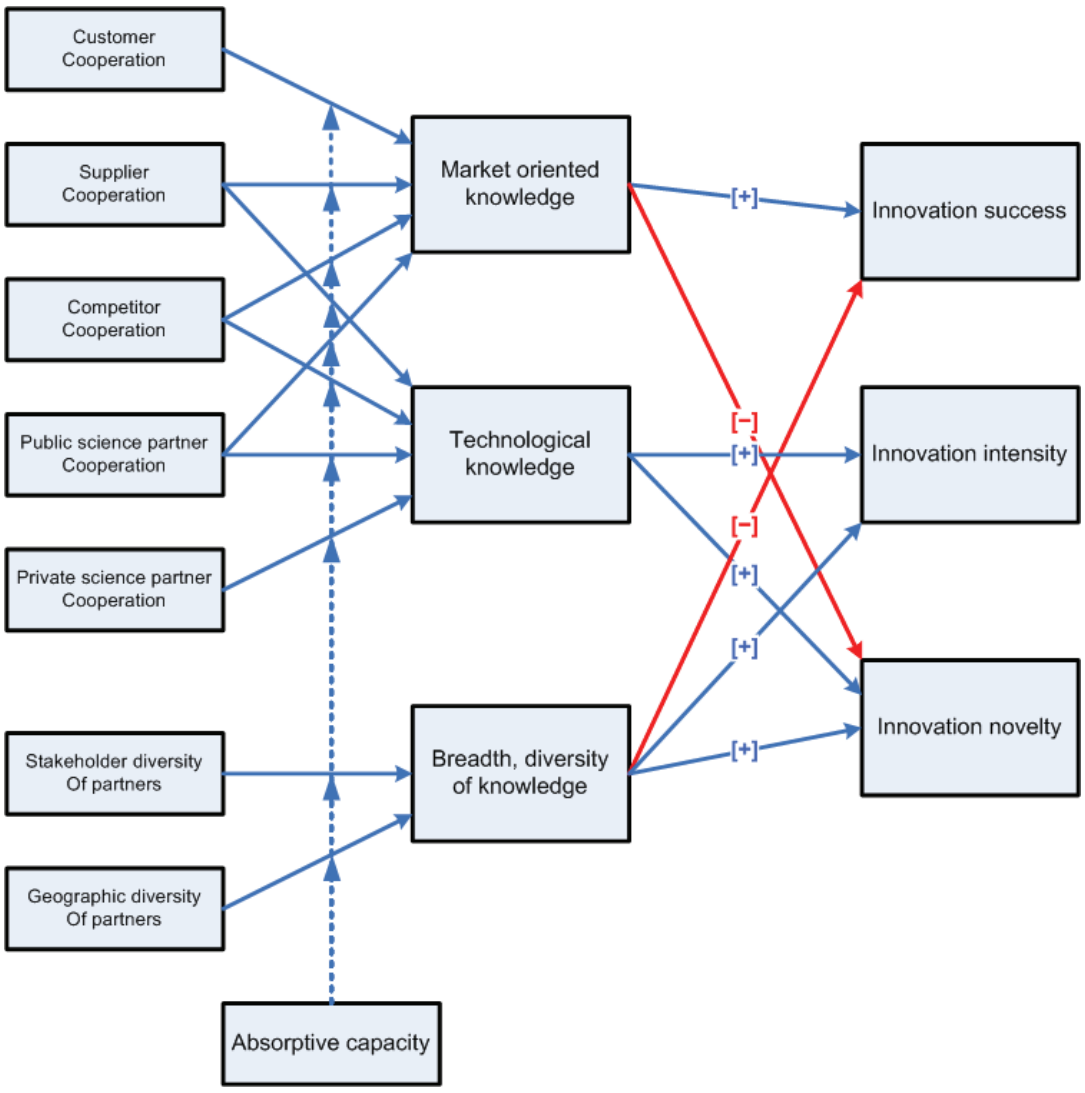

Figure 5-1 A knowledge based model on cooperation and innovation

This knowledge based conceptual model explains the relations between cooperation and innovation solely from a knowledge based perspective. However, in certain cases the knowledge based perspective is not expected to be complete or dominating in explaining the relations between cooperation and innovation as can be derived from chapter 4. The hypotheses and eventual research model derived from these hypotheses will not always be solely based on knowledge effects and can thus diverge from the knowledge based conceptual model.

5.2. Hypotheses

Based on the literature review as provided in chapter 4 and the knowledge based model as described in the previous paragraph, several hypotheses can be drawn for empirical investigation. This paragraph lists these hypotheses and a brief argumentation for them based on the findings of the literature review and theorized knowledge based model. To do this as clear and comprehensible as possible, for each type of cooperation the relevant part of the knowledge based, theoretical model is shown with the argumentation for the hypotheses.

Customer cooperation



Figure 5-2 Customer cooperation and innovation from the knowledge based view

As was argued, customer cooperation is mainly important for obtaining market oriented knowledge. This type of knowledge in combination with the limited mindset of customers is argued to mainly produce incremental innovation. With this type of cooperation, the close connection to the market is additionally expected to positively influence the commercial success of such innovations. This leads to the following hypotheses on customer cooperation:

1a) R&D cooperation with customers has a positive effect on the commercial success of innovation efforts of an organization

1b) R&D cooperation with customers has a negative effect on the novelty of innovation outputs of an organization

Supplier cooperation

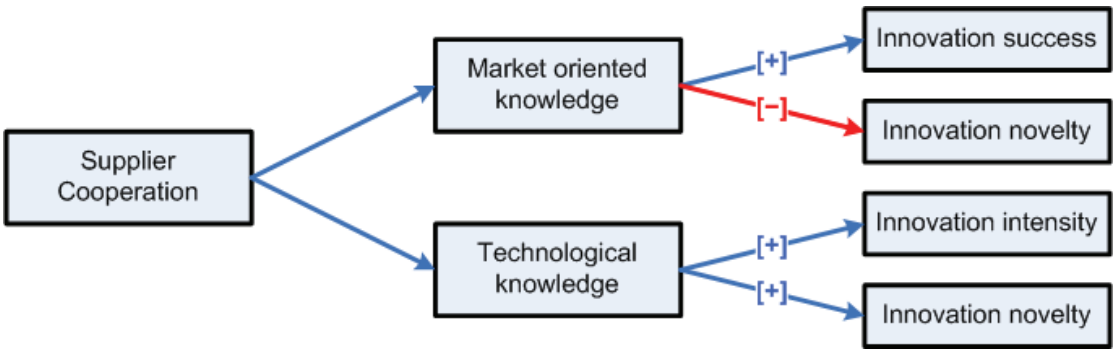

Figure 5-3 Supplier cooperation and innovation from the knowldge based view

Supplier cooperation is argued to provide access to both market oriented knowledge and technological knowledge. Therefore this type of cooperation can be expected to lead to incremental as well as more radical innovation. This broad set of (complementary) knowledge and the high efficiency of cooperation due to previous relations, are also argued to induce a higher intensity of innovation. This leads to the following hypotheses on supplier cooperation:

2a) R&D cooperation with suppliers has a positive effect on the intensity of innovation efforts of an organization

2b) R&D cooperation with suppliers has a positive effect on the commercial success of innovation efforts of an organization

Competitor cooperation

Competitor cooperation, like supplier cooperation, is expected to provide knowledge that is both market oriented as well as technological. However, in the case of competitor cooperation knowledge is not always the dominating factor in determining the motives and effects of cooperation. Where competitor cooperation is expected to take place in special instances and due to the specific technological knowledge of the competitors, this type of cooperation is argued to mainly produce radical innovation. Also due to their strong knowledge of and position in the market,

this type of cooperation is also expected to improve the commercial success of innovation. However, due to the expected inefficiency of cooperation between competitors and a reduced incentive to compete and thus innovate competitor cooperation is expected to have a negative effect on the intensity of innovation. This leads to the following hypotheses on competitor cooperation:

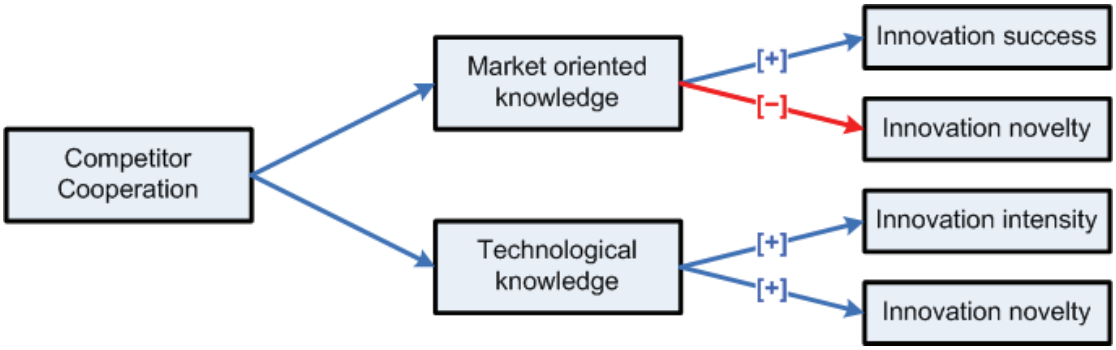

Figure 5-4 Competitor cooperation and innovation (solely) from the knowledge based view

3a) R&D cooperation with competitors has a negative effect on the intensity of innovation efforts of an organization

3b) R&D cooperation with competitors has a positive effect on the commercial success of innovation efforts of an organization

3c) R&D cooperation with competitors has a positive effect on the novelty of innovation outputs of an organization

Private science partner cooperation



Figure 5-5 Private science partner cooperation and innovation from knowledge based view

Due to the specialized technological knowledge of private science partners, cooperation with these types of partners is expected to mainly produce radical innovation. Also the access to such knowledge is argued to provide incentive to more intense innovation. This leads to the following hypotheses on private science partner cooperation:

4a) *R&D cooperation with private science partners has a positive effect on the intensity of innovation efforts of an organization*

4b) *R&D cooperation with private science partners has a positive effect on the novelty of innovation outputs of an organization*

Public science partner cooperation

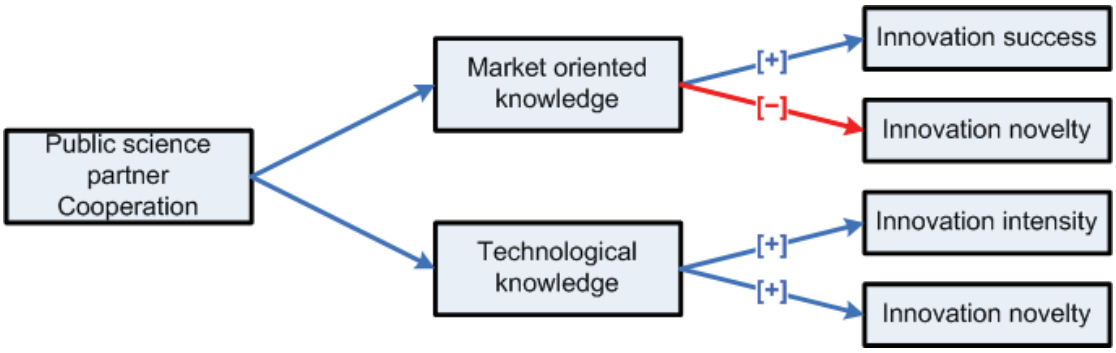

Figure 5-6 Public science partner cooperation and innovation from knowledge based view

Public science partners, like private science partners, posses specialized technological knowledge. Cooperation with these types of partners is therefore expected to mainly bring forth radical innovation and intensify innovation activities, similarly to cooperation with private science partners. However, unlike private science partners, public science partners have a strong position in the infrastructure of inter-organizational networks and actively play a role in the promotion of innovation. Therefore cooperation with public science partners can also be argued to have a positive effect on the commercial success of innovation. This leads to the following hypotheses on private public partner cooperation:

5a) *R&D cooperation with public science partners has a positive effect on the intensity of innovation efforts of an organization*

5b) *R&D cooperation with public science partners has a positive effect on the commercial success of innovation efforts of an organization*

5c) *R&D cooperation with public science partners has a positive effect on the novelty of innovation outputs of an organization*

Diversity of type of cooperation partners



Figure 5-7 (Any type of) Partner diversity and innovation from the knowledge based view

Meaningful diversity of cooperation partners was argued to increase the breadth and creativity of available knowledge for an organization. This breadth of knowledge is expected to lead to more creativity and radical innovation, and to increase the potential for and thus intensity of developing innovation. Two types of diversity of cooperation partners that are argued to be meaningful are the stakeholder type diversity and the diversity of geographic location of cooperation partners. The overall expected effects of diversity of cooperation partners then lead to the following similar hypotheses on these two types of diversity:

6a) *Diversity of type of stakeholders in R&D cooperation has a positive effect on the intensity of innovation efforts of an organization*

6b) *Diversity of type of stakeholders in R&D cooperation has a negative effect on the commercial success of innovation efforts of an organization*

6c) *Diversity of type of stakeholders in R&D cooperation has a positive effect on the novelty of innovation outputs of an organization*

7a) *Diversity of geographic location of cooperation partners in R&D cooperation has a positive effect on the intensity of innovation efforts of an organization*

7b) *Diversity of geographic location of cooperation partners in R&D cooperation has a negative effect on the commercial success of innovation efforts of an organization*

7c) *Diversity of geographic location of cooperation partners in R&D cooperation has a positive effect on the novelty of innovation outputs of an organization*

Absorptive capacity

Absorptive capacity, the ability to effectively extract and utilize the (external) knowledge that comes available through cooperation, was argued to intensify the knowledge effects of cooperation on innovation. From this I argue that absorptive capacity intensifies the effects of cooperation on innovation in general. This leads to the following hypothesis:

8) *High absorptive capacity of an organization intensifies the effects of R&D cooperation on innovation*

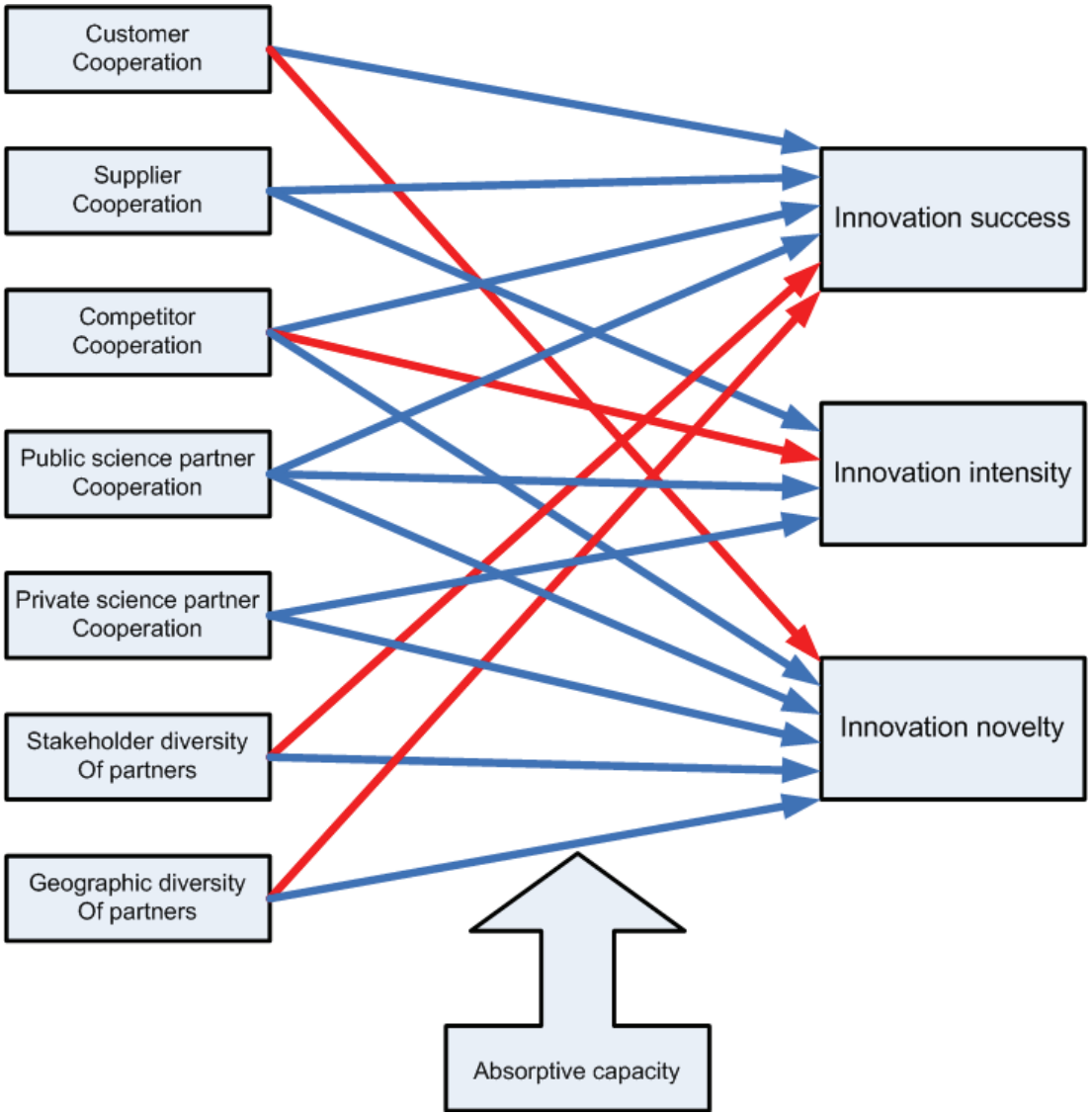

Figure 5-8 Research model for empirical investigation

The hypotheses on the relations between cooperation and innovation as they were discussed in this paragraph have been schematically portrayed in a research model for further analysis. This model is depicted in Figure 5-8 and will be tested empirically, as will be shown in the remaining chapters. In this research model the red arrows represent negative relations and the blue arrows represent positive relations.

6. Research methodology

As was discussed in the first chapter, this study is build up out of two phases: an explorative phase and an empirical phase. The literature review of the explorative phase which is presented in the previous chapters has led to the conceptual model and hypotheses as described in chapter 5. In the empirical phase the proposed relations will be tested statistically on basis of CIS data. To obtain this the relevant variables from the model and hypotheses will be analyzed in several regression models.

This chapter describes how the different variables will be measured empirically from the data and how they will fit into the regression models.

6.1. Community Innovation Survey (CIS)

As was mentioned earlier, this research is completely based on data from the community innovation survey (CIS). The community innovation survey is the main statistical instrument of the European Union that allows the monitoring of Europe's progress in the area of innovation. The CIS creates a better understanding of the innovation process and analyzes the effects of innovation on the economy (on competitiveness, employment, economic growth, trade patterns, etc.). The CIS has been carried out for the first time in 1992. CIS2 took place in 1996, CIS3 in 2001 and the most recent version CIS4 took place in 2004 (Eurostat 2007). In the most recent version(s) of the CIS some attention has also been directed at cooperative activity in innovation, which provides the main pillar for this research. The responsibility for the survey at a national level is in most cases with the National Statistical Office or a national Ministry, in this case the Dutch central bureau of statistics (CBS).

The Dutch dataset contains data on approximately 10 000 Dutch organizations of all sizes and industry that participated with the survey. This includes organizations that report no innovative activity as well. As explained earlier, for this research only organizations engaging in product innovation were of interest. Therefore non product innovators were filtered out leaving a data sample of 3090 organizations available for statistical analysis.

6.2. Measurement

This paragraph explains how the relevant variables from the model will be operationalized and measured from the CIS data set. A complete overview of all the relevant variables and their measurement is presented in Table 6-1 at the end of this chapter.

6.2.1. Dependent variables

As was discussed in chapter 3 on innovation, this study analyzes innovation on three dimensions, namely the innovation intensity, innovation success and innovation novelty. The CIS dataset can provide many different measures or proxies for these dimensions. However, since numerical, ratio scale measurement of the dependent variables will provide more meaningful results, the selection has been limited to numerical data. The following paragraphs will discuss the selected proxies and provide argumentation for the selection.

Innovation intensity

As was discussed in chapter 3, I argue that innovation intensity or activity is best measured from input measures of innovation. Traditionally innovation intensity is not only measured by the innovative inputs but also by outputs, like through counting patents or number of innovations (Love and Roper 2001; Hagedoorn and Cloodt 2003). Such measures can be valuable, although in the case of innovation intensity I argue that such measures neglect failed innovation projects and ongoing research. Also there is the issue that the tendency to patent or introduce innovation is highly dependent to the culture of an organization.

True innovation intensity or activity however is logically linked to R&D intensity, which can be measured from traditional measures, like R&D expenditure in comparison to sales or R&D personnel in comparison to the total amount of employees. Both measures are available in the CIS data set and both will be applied to determine effects on innovation intensity. The measures are calculated as follows:

$$Innovation\ intensity\ 1 = \frac{R\&D\ expenditure}{total\ sales}$$

$$Innovation\ intensity\ 2 = \frac{R\&D\ personnel\ (FTE)}{total\ personnel\ (FTE)}$$

Innovation success

In chapter 3 I argued that innovation success can mainly be measured from output measures of innovation. The measurement of innovative performance in general, with the rise of large scale (inter)national innovation surveys like CIS, is recently often drawn from sales of innovative products in comparison to total sales (Kleinknecht, van Montfort et al. 2002; Smith 2004). These measures seem to be superior to the traditional measures of innovation performance (Kleinknecht, van Montfort et al. 2002). However, this measure for innovation performance in general incorporates both innovation intensity as well as the (commercial) success of innovation. I argue that in order to purely measure innovation success, the output of innovation has to be related to the inputs that were utilized, comparable to determining return on investment. This approach seems to be novel in the case of innovation, but it is often indirectly integrated in determining overall innovation performance which is usually the variable of interest in the literature.

From the longitudinal CIS data it is possible to construct such a measure by determining the ratio between sales from new and improved products, which is the effective output of innovation, and the average R&D expenditure of a preceding period, which depict the input for creating innovation. The length of the period here is naturally dependent on the time lag between the R&D expenditure and innovation outputs, which in general is assumed to be 3-5 years (Feldman and Florida 1994; Klaassen, Miketa et al. 2003). In constructing the measure the average R&D expenditure was calculated over a period of 6 years (1998-2004) based one the two yearly CIS data on R&D expenditure. However, due to the lack of overlap of respondents between the different series of the CIS surveys this strongly reduced the available number of observations. This was solved by making the assumption that the R&D expenditure for a certain company is fairly stable over the years. Under this assumption it is allowed to neglect any missing observations of R&D expenditure for certain year(s) in calculating the average R&D expenditure for the period. The assumption was also tested by running regressions of the R&D expenditures of earlier

years with the R&D expenditure in 2004. These regression show a highly significant relations with regression coefficients close to 1, which supports the assumption that the R&D expenditure of an organization in general does not change a lot over the years. The statistical output of these regressions is provided in Appendix B. The formula for innovation success eventually yields:

$$Innovation\ success = \frac{innovative\ sales}{average\ R\&D\ expenditure\ [1998\text{-}2004]}$$

Descriptive analysis of this variable showed that there was a very large spread of values for this variable and that the data was very skewed. In this form the data is inappropriate for statistical analysis, because regression results would be dominated by extremely high valued observations. Therefore it was necessary to apply a nonlinear transformation, which is allowed as long as no conclusions are drawn on the strength of relationships that are found from the analysis. Because of the many zero observations, a logarithmic transformation was not suitable so a power transformation was selected. A fourth power root was taken to flatten the data and as such remove extremely high values from the model.

Innovation novelty

In the earlier discussion on the innovation typology of radical vs. incremental innovation, it was argued that to determine the novelty of an innovation for empirical analysis, the newness of the innovation in the market will be applied. This type of measurement of innovation novelty has been adopted in the CIS survey solely by distinguishing between innovations new to the firm and innovations new to the market. This distinction will be utilized to determine a measure for an organization's innovation novelty, which is the ability or tendency to produce novel innovation. Based on the assumption that the sales of a certain type of innovation provide a good indicator for an organization's tendency to create that type of innovation, the measure for innovation (market) novelty will be based on data about the sales of products new to the market and sales of products new to the firm. This data is the only numerical data available in the CIS database that allows for the construct of an innovation novelty measure.

In constructing a measure for relative (market) novelty of innovation at a certain organization I argue that two factors are important. Firstly and most importantly, there is the ratio of sales of products new to the market as part of the total of innovative sales, which also include sales of products only new to the firm. It can be argued that when the larger part of an organization's innovative sales come from products completely new to the market, this company is more focused on novel or radical innovation rather than incremental innovation.

However, when only determining novelty based on the ratio of sales from products new to the market as part of the total of innovative sales, the aspect of the size of innovative sales is neglected, which I will illustrate through an example: An organization (A) gets half of the total turnover from products new to the market and half of the total turnover from products new to the firm. Another organization (B) only gets one percent of the total turnover from products new to the market and one percent of the total turnover from product new to the firm. These organizations have the same ratio of sales from products new to the market as part of the total of innovative sales. However, it can be argued that the first organization (A) is better in creating novel innovation, because it gets a much greater part of its total turnover from products new to the market. Therefore the ratio of sales from products new to the market as part of the total turnover can also be argued to be of importance here. Therefore I opted for constructing two measures for innovation novelty: One measure only addressing the ratio of sales of products new to the market as part of the total of innovative sales:

$$Innovation\ novelty\ 1 = \frac{sales\ products\ new\ to\ market}{innovative\ sales}$$

And another one which also includes the ratio of sales from products new to the market as part of the total turnover.

$$Innovation\ novelty\ 2 = \frac{sales\ products\ new\ to\ market}{innovative\ sales} \times \frac{sales\ products\ new\ to\ market}{total\ sales}$$

It should be noted that the latter measure for innovation novelty to some extend also portrays an organization's innovation success. If an organization is very capable

of bringing innovation to the market, this organization will logically get a greater part of its turnover from innovative products (new to the market) as compared to an organization with low innovation success.

Logically the possible values here for innovation market novelty are between 0, for an organization not getting any sales from new products, and 1, for an organization getting all of its sales from completely new products.

6.2.2. Independent variables

As was discussed in chapter 2, in operationalizing cooperation this study focuses on partner characteristics. It was determined that the type of stakeholder, diversity of the type of stakeholders and the geographic diversity of cooperation partners are relevant variables in this context for which measures can be constructed from the CIS dataset. This paragraph discusses the empirical measurement of these independent variables.

Stakeholder type of cooperation partners

The CIS survey contains information on whether an organization has cooperated with several types of partners in innovation activities as dummy variables as can be seen in Appendix C containing the survey for 2004. As discussed in chapter 2 these dummies can be combined to determine whether an organization has cooperated with 5 types of stakeholders of interest, namely customers, suppliers, competitors, private science partners and public science partners. This means that for each stakeholder type a dummy will be created to indicate any cooperation with that type of partner. This measure can directly be used as a proxy for cooperation with that type of stakeholder in statistical analysis.

Since for each type of stakeholder (at least) four dummies are available portraying whether there was cooperation with a certain type of stakeholder in the Netherlands, other EU countries, the United States or any other country, it could also be possible to add these four dummies to create numerical values portraying the strength or amount of cooperation ties with a certain stakeholder. This approach which was applied by Feams et al (Faems, Van Looy et al. 2005) introduces a higher level of detail into the

analysis. However since it is impossible to interpret the meaning or value of the separate dummies this approach is not very scientific. For this research therefore only the analysis based on previously explained dummies will be discussed.

Diversity of partner types

As was explained above five dummies will be constructed that indicate whether an organization has cooperated with each of the five relevant types of stakeholders. In a similar fashion four dummies can be constructed from the CSI data set to determine whether an organization has cooperated with partners in The Netherlands, another European company, the United States or any other country. In determining proxies for stakeholder type diversity and geographic diversity of cooperation partners, these dummies are the available data source.

One way to achieve this is by adding the dummies, creating scores from 1 to 5 for stakeholder type diversity and 1 to 4 for geographic diversity. This method was applied by Laursen and Salter to determine the breadth and depth of information searches (Laursen and Salter 2006). However, this method does not give an accurate representation for diversity, which can be explained as follows. The difference of diversity between a set of 19 different cases and 20 different cases is strongly different (smaller) than the difference of diversity between a set of 2 different cases and a set of 3 cases types. To account for this, it is better to apply one of the diversity indices that are strongly established in biological, physical, social and management sciences.

Throughout the literature the two main indices to determine diversity are Simpson's diversity index and Shannon's diversity index (Patil and Taillie 1982; McDonald and Dimmick 2003). Simpson's diversity index reflects the probability that two elements picked randomly from a population come from the same category. It is a straightforward probabilistic definition of diversity. Mathematically Shannon's diversity index is very similar to Simpson's diversity index, but includes a logarithmic transformation which makes it more accurate (McDonald and Dimmick 2003). Simpson's diversity index is also applied in economics to determine (industrial) concentration under the name Herfindahl index (Patil and Taillie 1982). The two indices are explained below.

Simpson's diversity index (in economics also known as Herfindahl index):

$$H = \sum_{j=1}^{N} (P_j/P_T)^2$$

Where P_j represents the number of partners of category j and P_T represents the total amount of partners. N represents the total number of categories that have been established.

Important to note is that the Simpson's or Herfindahl index traditionally meant to measure concentration, the opposite of diversity, and should therefore be reversed by subtracting the index from 1:

$$H = 1 - \sum_{j=1}^{N} (P_j/P_T)^2$$

Note that the higher is the value of this index, the more diverse would an organization's partners be. For example, H would equal 0 if there were a single category in which the company would have partners, while it would tend toward 1 if partners would be equally distributed over a large number of categories. ($0 \leq H \leq 1$)

Shannon's entropy

$$E = -\sum_{i=1}^{I} P_i \ ln(1/P_i)$$

Where P_j represents the number of partners of category j in proportion to the total amount of partners of the firm. N represents the total number of categories that have been established.

Note that with Shannon's entropy function, the maximum value for E is attained when all countries contribute equally to the firm's operations (sales), thus when international diversity is maximized. When diversity is minimized, thus when the company is active in only one single country, E is zero. ($0 \leq E \leq ln(N)$)

Since the data for the types of partners is only available as dummies, the logarithmic transformation from the Shannon's index can become problematic and does not improve accuracy. In addition, the relatively simple mathematics of Simpson's diversity index can be preferable in a statistical environment. Therefore the Simpson's or Herfindahl index will be applied to measure partner diversity for both stakeholder type and geographic location.

Although it does not seem scientifically solid to utilize dummies in the arithmetic operation of the diversity index, it is possible since only cases are counted. In this case, with dummy variables however, the number of partners of a certain category can not exceed 1, limiting the diversity index to only several possible values. Nevertheless, applying a diversity index is the best representation of diversity that is possible from this type of data as was confirmed through an e-mail discussion between Dr. Ronald Dekker and Prof. Dr. Yiannis Spanos, specialists on economic statistics.

Absorptive capacity

As was discussed in chapters 4 and 5, the absorptive capacity is introduced into the conceptual model as a moderating variable on the relation between cooperation and knowledge and thus also indirectly on the relation between cooperation and innovation. I argued that Absorptive capacity is not only determined by (internal) knowledge developing through continuous R&D (Cohen and Levinthal 1990), but also by competencies of cooperation and communication with external partners developed by prior experience in cooperation. Therefore a proxy for absorptive capacity integrating both prior experience in cooperation and (internal) knowledge developing activities would be preferable. However, data on cooperation experience would require a merge between different versions of the CIS, which would greatly reduce available date sample due to the lack of overlap of respondents between the different series of the CIS surveys. Also, including cooperation experience from similar data as the cooperation dependents in the models could strongly effect and distort the statistical analysis. Therefore it was decided to only apply a measure for absorptive capacity on continuous R&D activity at a firm as proposed by Cohen and Levinthal.

The CIS survey has data available on whether the organization is engaged in intramural R&D and whether this effort is ongoing or occasional. From this data a dummy will be constructed representing a continuous R&D effort by the organization, which will be used to provide a proxy for absorptive capacity.

In order to be able to test whether there is a direct moderating effect from this absorptive capacity on the relation between cooperation and innovation, product terms have to be created to test for relevant interaction effects. Due to the fact that

absorptive capacity is represented by a dummy, these product terms can simply be created by multiplying the absorptive capacity dummy with the cooperation variables. Some more explanation on the interpretation of these product variables will be provided in chapter 7.

6.2.3. Control variables

Several other variables that are also expected to have an impact on the three dimensions of innovation will be incorporated as control variables in the statistical models.

Firstly, the industry sector an organization operates in, is expected to have influence on innovation (Acs and Audretsch 1988). For instance high tech industries can be expected to engage more in innovation. The industry sectors are introduced into the model by creating dummies for the sectors on basis of the publication level industry classification as applied by CBS. The SBI '93 (Standaard BedrijfsIndeling '93) is the industry classification applied by CBS, which is derived from the International Standard Industrial Classification (ISIC). These applied SBI sectors and there codes can be located in Appendix D.

Also the size of an organization is of importance (Acs and Audretsch 1988; Cassiman and Veugelers 2002). The size of an organization has effects on both innovation activity and cooperation activity. It has been shown that small organizations in general are more innovative than larger ones (Acs and Audretsch 1990). Also, large organizations are more often engaged in cooperation than small organizations (Cassiman and Veugelers 2002). Organization size is introduced into the model as the logarithmic transformation of the number of employees.

Furthermore, whether the organization is part of a group or holding can be relevant (Belderbos, Carree et al. 2004). If an organization is part of a group, it will prefer to cooperate with an internal party within the group. Also it can be predetermined in a (multinational) group which departments or locations are engaged in innovation and which not. By not being autonomous, figures for such an organization can thus be distorted. The CIS dataset contains a dummy variable determining whether the organization is part of a group or holding.

Table 6-1 Description and measurement of variables

Variable name	Description
Independent variables	
Innovation intensity 1	R&D expenditure divided by total sales of the organization
Innovation intensity 2	Number of R&D personnel divided by total number of employees of the organization (in FTE)
Innovation success	4th power root of sales from new products divided by the average R&D expenditure from 1998-2004
innovation novelty 1	Sales from products new to the market divided by sales from all new products, multiplied with, sales from products new to the market divided by total sales
innovation novelty 2	Sales from products new to the market divided by sales from all new products
Dependent variables	
Customer cooperation (custcoop)	1 if the organization reported cooperation on innovation activities with customers or clients, else 0
Supplier cooperation (suppcoop)	1 if the organization reported cooperation on innovation activities with suppliers, else 0
Competitor cooperation (compcoop)	1 if the organization reported cooperation on innovation activities with competitors or other organizations in the same sector, else 0
Private science partner cooperation (scprcoop)	1 if the organization reported cooperation on innovation activities with consultants, commercial labs or research institutes, else 0
Public science partner cooperation (scprcoop)	1 if the organization reported cooperation on innovation activities with universities, other higher education institutions, government or public research institutes, else 0
Stakeholder type diversity (stakediversity)	Herfindahl index of the cooperation stakeholder categories (customer, supplier, competitor, private science partner, public science partner)
Geographic diversity (geodiversity)	Herfindahl index of the cooperation partner location categories (Netherlands, other Europe, USA, all other countries)
Absorptive capacity (abscap)	1 if the company engages in continuous intramural R&D, else 0
Product terms (abs_*variable*)	Multiplication of absorptive capacity dummy and a certain (cooperation) dummy '*variable*'
Control variables	
Domestic enterprise group (group)	1 if the organization is part of a domestic enterprise group, else 0
Foreign multinational (foreignmult)	1 if the organization is part of an enterprise group with the head office located outside the Netherlands, else 0
Organization size (logemp2004)	logarithm of the total number of employees
Organization industry sector (sbi_*xx*)	Dummies for each publication level SBI code

Finally, whether an organization belongs to a group or holding that is domestic or foreign can be of influence (Belderbos, Carree et al. 2004). Organizations with a foreign origination are more likely to have foreign partners. Also there is the possibility that a foreign origination has a specific effect on an organization's culture and thus its propensity to cooperate or innovate. The CIS dataset contains information about the location of the head office of the group or holding. From this a dummy variable can be created determining whether the head office is located in the Netherlands or not.

6.3. Statistical methods and models

In order to statistically determine the relations between the established independent and dependent variables based on the CIS data, applying some type of (multiple) regression is the logical choice for models with many variables. To determine what type of statistical regression would fit best in this case, the data had to be examined. By studying the descriptive plots on the distribution of the dependent variables as provided in Appendix E, it can be seen that the data in question has some specific characteristics. All dependent variables are non-negative and have many zero observations. This type of dependent variable is called a limited or censored dependent variable. This type of data can best dealt with through special methods. Normal OLS regression estimation is possible, but would probably yield biased or even inconsistent estimators. The best method to approach this type of data is the TOBIT regression model (Wooldridge 2003). This method is based on a latent variable model and can account for both left-censored and right-censored dependent variables. Left-censored data here is when a variable is censored below a certain value, in this case at zero, right-censored data is when it is censored above a certain value. An important issue with the TOBIT model is that the model is very sensitive to violations of the assumptions of homoskedasticity or normality (Wooldridge 2003). Since all models displayed a strong suspicion of some heteroskedasticity and non-normality, the standard TOBIT regression model could be inconsistent and thus is not a very suitable or reliable method of analysis here. In order to deal with the heteroskedasticity and non-normality, interval regression technique was selected for the main analysis. Interval regression is a generalization of TOBIT regression for which the statistical package Stata contains a robust standard errors option. This

option makes the model robust against some heteroskedasticity and non-normality. In practice, all three possible regression methods, namely OLS, TOBIT and interval regression, have been carried out. The results were found to largely corroborate with each other. Nevertheless, in this paper only the results from interval regression will be discussed since these are the most reliable

All regression models have also been run through an automated stepwise selection method to verify the initial result of the complete regression results.

6.3.1. Statistical models

In the chapter on measurement it was explained that four different independent variables are introduced for statistical analysis, two portraying innovation intensity, one for innovation success and one for innovation novelty. For each independent variable three models have been constructed.

First a model is constructed containing the cooperation dummies, the diversity variables and all the control variables.

Secondly a model is constructed including all the variables from the first model but with the addition of the absorptive capacity dummy as an extra dependent.

Thirdly a model is constructed including all the variables from the second model, with the addition of the product terms for the cooperation (and diversity) variables and absorptive capacity variable.

Table 6-2 Overview of the relevant (interval) regression models

	Dependent variable				
	Innovation intensity 1	Innovation intensity 2	Innovation success	Innovation novelty 1	Innovation novelty 2
Independent variables					
Cooperation variables & control variables	Model 1a	Model 2a	Model 3a	Model 4a	Model 5a
Coop. Variables, absorptive capacity & control variables	Model 1b	Model 2b	Model 3b	Model 4b	Model 5b
Coop. Variables, absorptive capacity, product terms and control variables	Model 1c	Model 2c	Model 3c	Model 4c	Model 5c

This leads to fifteen regression models in total as is schematically shown in Table 6-2. All twelve models have been estimated using OLS, TOBIT and interval regression with both cooperation variables based on dummies as well as cooperation variables based on aggregated numerical values. In the report only the models estimated with (robust) interval regression based on cooperation dummies will be discussed.

7. Empirical results

This chapter will discuss the main results from the statistical analysis. Significant results will be reported and investigated to what extend they support the hypotheses as presented in chapter 5.

7.1. Descriptive statistics

Table 7-1 Descriptive statistics

Variable	Var. type	Obs.	Mean	St. error	Min.	Max.
Relevant variables for model construction						
Total turnover 2004	Numerical	3090	94923.3	474667.4	0	11700000
Turnover share products new to the market	Numerical	3090	0.079	0.163	0	1
Turnover share products new to the firm	Numerical	3090	0.086	0.170	0	1
Turnover share unchanged products	Numerical	3090	0.835	0.237	0	1
Total R&D personnel 2004	Numerical	2335	15.4	152.3	0	6636.5
Total employees 2004	Numerical	3090	328.6	1634.0	1	44041
Total R&D expenditure 2004	Numerical	3090	2081.1	24732.3	0	1213536
Average R&D expenditure 1998-2004	Numerical	3090	2098.1	23585.7	0	1139341
Cooperation in innovation	Dummy	3090	0.501	0.500	0	1
Coop. with Dutch partner(s)	Dummy	3090	0.462	0.499	0	1
Coop. with other European partner(s)	Dummy	3090	0.274	0.446	0	1
Coop. with US partner(s)	Dummy	3090	0.101	0.301	0	1
Coop. with partner(s) from other countries	Dummy	3090	0.082	0.274	0	1
Independent variables						
Innovation intensity 1	Numerical	3080	0.274	4.634	0	183.50
Innovation intensity 2	Numerical	2335	0.094	0.467	0	18.4
innovation success	Numerical	2671	69.7	1393.5	0	52889.04
4th power root innovation success	Numerical	2671	1.404	1.157	0	15.16
Innovation novelty 1	Numerical	3090	0.366	0.408	0	1
Innovation novelty 2	Numerical	3090	0.063	0.153	0	1
Dependent variables						
Geodiversity	Numerical	3090	0.157	0.262	0	0.75
Custcoop	Dummy	3090	0.280	0.449	0	1
Suppcoop	Dummy	3090	0.386	0.487	0	1
Compcoop	Dummy	3090	0.169	0.375	0	1
Prsccoop	Dummy	3090	0.223	0.416	0	1
Pusccoop	Dummy	3090	0.217	0.413	0	1
Stakediversity	Dummy	3090	0.233	0.319	0	0.8
Logemp2004	Numerical	3090	1.925	0.597	0	4.64
Foreignmult	Dummy	1814	0.379	0.485	0	1
Group	Dummy	3090	0.612	0.487	0	1
absorptive capacity	Dummy	3089	0.542	0.498	0	1
abs_geodiversity	Dummy	3090	0.121	0.241	0	0.75
abs_custco	Dummy	3090	0.200	0.400	0	1
abs_suppco	Dummy	3090	0.253	0.435	0	1
abs_compco	Dummy	3090	0.110	0.313	0	1
ad_scprco	Dummy	3090	0.161	0.368	0	1
ad_scpuco	Dummy	3090	0.165	0.371	0	1
ad_stakediv	Dummy	3090	0.165	0.292	0	0.8

This chapter provides the descriptive statistics for all the important variables that were used to construct the interval regression models. These descriptive statistics are provided in Table 7-1. As can be seen from Table 7-1, most of the relevant variables are dummies, for which the descriptive statistics are hard to interpret. For these variables distribution plots are often more insightful. Here several distribution plots for interesting variables are provided and briefly discussed.

First off, one of the most interesting distributions here is that of the type cooperation partners, denoting which type of partners are the most common in cooperating on R&D activities and which are not. This distribution is schematically shown in Figure 7-1. The most common type of cooperation partners are suppliers followed by customers. This is not unexpected, since organizations are usually familiar with cooperating with their suppliers and customers and have a high level of synergy and trust with these types of cooperation partners. Competitors are the least common types of cooperation partners which can also be expected on basis of the distrust or other cooperative barriers that exists between competitors.

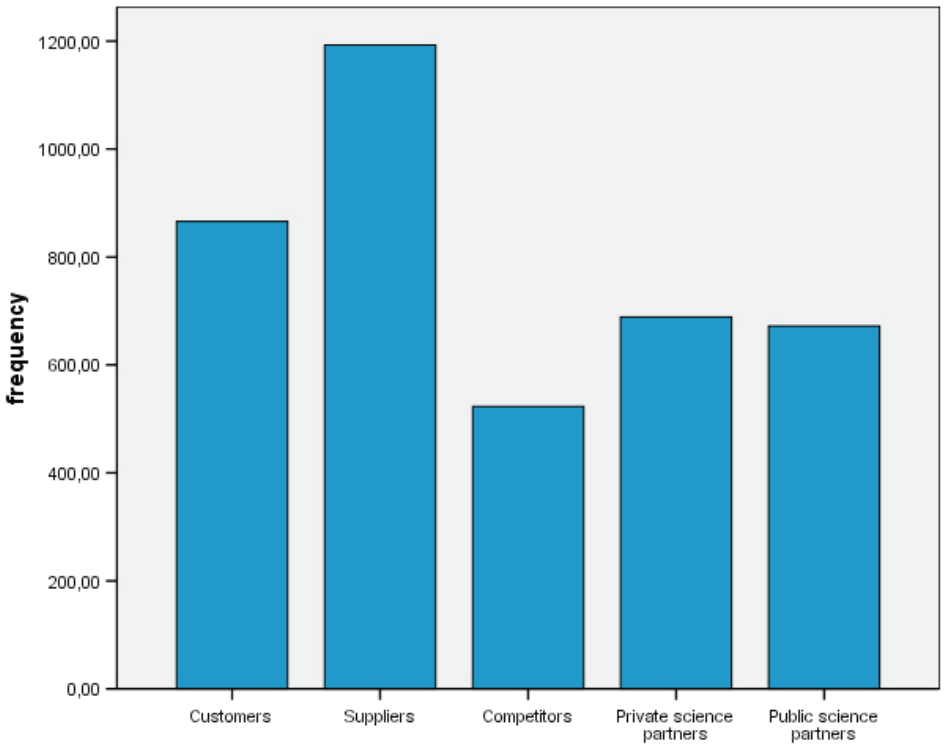

Figure 7-1 Frequency of stakeholder types of cooperation partners

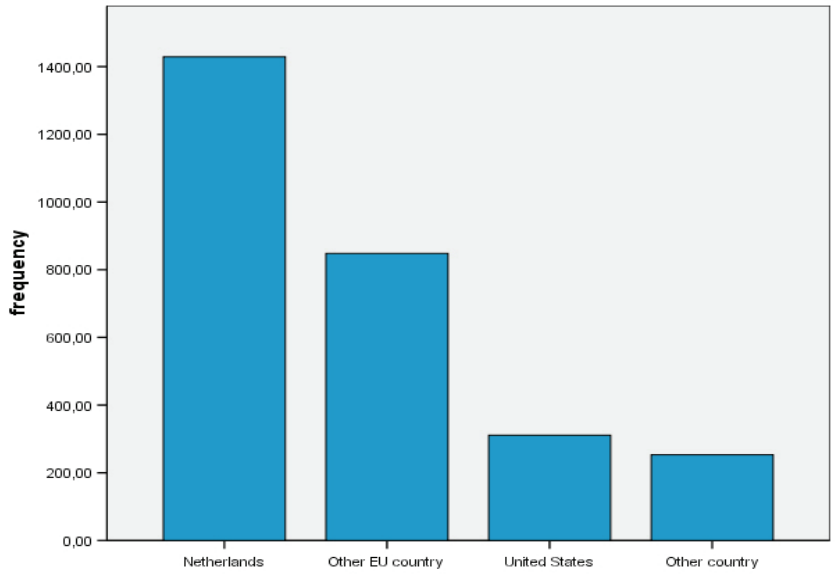

Figure 7-2 Frequency of geographic location of cooperation partners

Another relevant distribution, that of geographical location of partners, is portrayed in Figure 7-2. Logically, cooperation is the most common with cooperation partners in geographical proximity. This means that organizations in the Netherlands are more inclined to cooperate with either other Dutch organizations or European organizations rather than organizations in the US or other countries.

The distributions for the diversity measures, both stakeholder and geographic diversity of partners, show that in general organizations do not cooperate with a diverse set of partners as can be seen in Figure 7-3 and Figure 7-4. This suggests that organizations tend to focus on cooperating with a few (types) of partner.

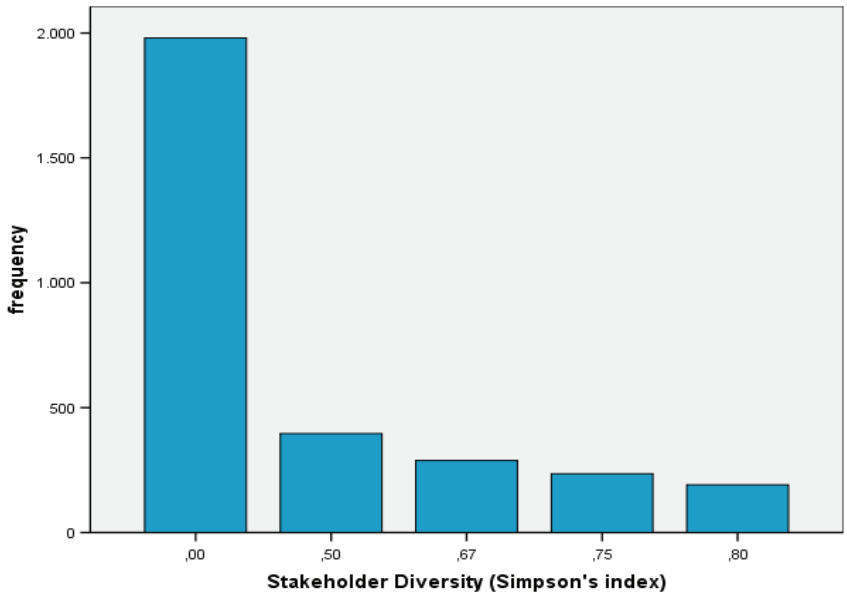

Figure 7-3 Distribution plot for stakeholder diversity of partners

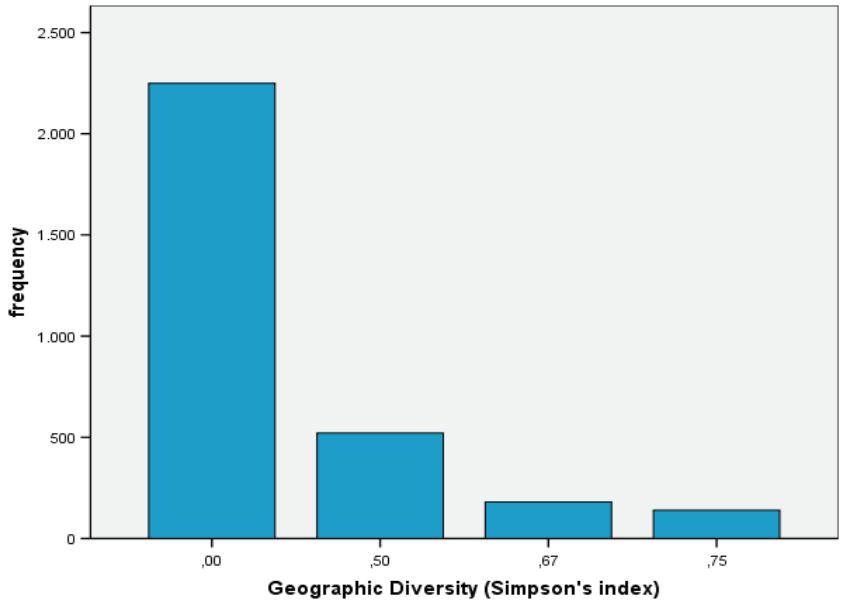

Figure 7-4 Distribution plot for geographic diversity of partners

Finally, the last descriptive plot is that of the distribution of the organizations in the sample according to their industry sector classification based on the SBI '93 publication level. As can be seen in Figure 7-5 there seems to be a quite even spread of the sample over the different industry sectors. The only two slightly overcrowded sectors are Retail (SBI 51) and information services (SBI 74), which shows that in The Netherlands retailers and information service providers are the most common type of organizations which was to be expected.

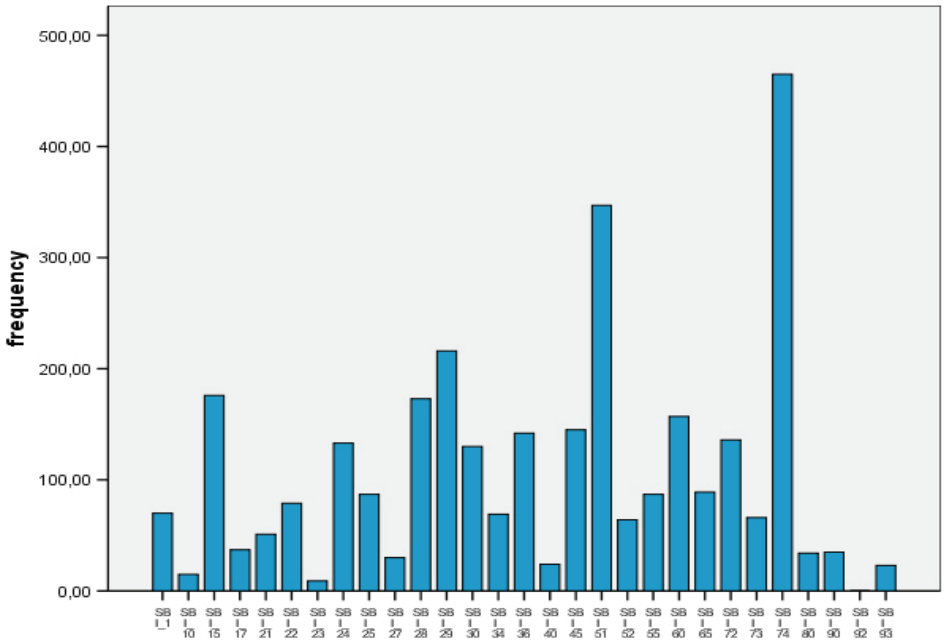

Figure 7-5 Distribution of organizations´ industry sectors throughout the sample

7.2. Interval regression models

In this chapter the results will be discussed from the regression models as they have been proposed. The tables with results have been slightly modified to be suitable for the main text. To keep the tables concise and comprehensive, the industry dummies are removed from the tables presented in the main text. The complete regression models with industry dummies are available in Appendix F. Important to note is that the pseudo R-squared provided with the models is the McKelvey & Zavoina pseudo R-squared (Veall and Zimmermann 1996)[1].

7.2.1. Interval regression models with product terms

As was mentioned in the previous chapter, product terms between absorptive capacity and cooperation variables are entered into the regression models to determine whether any moderating effect of absorptive capacity on cooperation exists. Some additional explanation is needed here for the interpretation of the regression models with these product terms. Most of the following explanation is derived from the textbook of statistics by Wooldridge (Wooldridge 2003)

The variable for absorptive capacity is a dummy, as are the variables denoting cooperation with a certain type of stakeholder. To obtain the product terms between these variables, the dummies were multiplied creating a new dummy, the product term. An example would be where the dummy for customer cooperation (custcoop) is multiplied with the dummy for absorptive capacity (abscap) to create the product term (abs_custco). Part of the regression model for innovation intensity 1 (innint1) would then look as follows:

[1] *The standard pseudo R-squared provided by the Stata statistical analysis software package is the McFadden pseudo R-squared which is in fact not valid for interval regression and TOBIT (Veall and Zimmerman, 1996). Therefore I have included the McKelvey & Zavoina pseudo R-squared which was found to be the most consistent for interval regression (Veall and Zimmerman, 1996). Other methods to determine the goodness of fit are evaluating the Chi-squared values and the log likelihood values of the interval regression models (Wooldridge, 2003).*

$$Innint1 = \beta 0 + \beta_1 \times abscap + \beta_2 \times custcoop + \beta_3 \times abs_custco + ...$$

The addition of the product term allows the contribution of customer cooperation (custcoop) to depend on the absorptive capacity (abscap) of an organization. If there is indeed interaction between custcoop and abscap, the regression coefficient for the interaction term ($\beta_{3)}$ should be significantly different from zero. Additionally, if absorptive capacity intensifies or amplifies the effects of cooperation, the sign for the regression coefficient for the interaction term ($\beta_{3)}$ should be the same as for the regression coefficient for customer cooperation in general. Important to note is that β_2 here does not represent the regression coefficient for customer cooperation in general, but only represents the effect of customer cooperation if absorptive capacity is zero. Similarly β_1 represents the effect of absorptive capacity only when customer cooperation is zero. To obtain the regression coefficient for customer cooperation in general, a model without the product terms should be applied.

The case of the product terms between absorptive capacity and the diversity measures, which are not dummies, is slightly different. Here introducing the product terms allow for a difference in slope for the regression coefficients for these diversity measures. A similar example as above with geographic diversity (geodiversity) instead of customer cooperation would look like:

$$Innint1 = \beta 0 + \beta_1 \times abscap + \beta_2 \times geodiverse + \beta_3 \times abs_geodiv + ...$$

This can be rewritten as follows:

$$Innint1 = (\beta 0 + \beta_1 \times abscap) + (\beta_2 + \beta_3 \times abscap) \times geodiversity + ...$$

As can be seen from this equation, the slope for geographic diversity (denoted by ($\beta_2 + \beta_3$*abscap)) depends on the absorptive capacity of an organization if β_3 is significantly different from zero. Again, if absorptive capacity intensifies or amplifies the effects of diversity, the sign for the regression coefficient for the interaction term ($\beta_{3)}$ should be the same as for the regression coefficient for geographic diversity in general, generating a steeper slope. Therefore in the context of this research the

interpretation of the interaction effects for this case are similar to the case in which both variables are dummies.

7.2.2. Innovation intensity

As was discussed earlier, two independent variables have been constructed to indicate innovation intensity. The regression models for each of these different indicators will be analyzed separately after which similarities and inconsistencies between the results of the different models can be discussed.

Innovation intensity 1

Table 7-2 Interval regression results with dependent variable innovation intensity 1

	Model 1a		Model 1b		Model 1c	
Independent variables	**Coeff.**	**Robust S.E.**	**Coeff.**	**Robust S.E.**	**Coeff.**	**Robust S.E.**
geodiversity	0.0631 ***	0.0122	0.0570 ***	0.0118	0.0086	0.0156
custcoop	-0.0153 *	0.0092	-0.0143	0.0091	-0.0237 *	0.0133
suppcoop	-0.0037	0.0076	-0.0028	0.0077	0.0274 **	0.0118
compcoop	-0.0028	0.0075	-0.0019	0.0074	-0.0044	0.0130
scprcoop	0.0069	0.0093	0.0064	0.0092	0.0030	0.0136
scpucoop	0.0091	0.0078	0.0068	0.0077	0.0045	0.0115
stakediversity	0.0122	0.0253	0.0078	0.0253	0.0130	0.0379
logemp2004	-0.0192 ***	0.0049	-0.0216 ***	0.0050	-0.0217 ***	0.0049
foreignmult	-0.0154 ***	0.0043	-0.0146 ***	0.0043	-0.0131 ***	0.0042
group	0.0001	0.0170	-0.0035	0.0167	-0.0019	0.0166
abscap			0.0298 ***	0.0044	0.0332 ***	0.0054
abs_geodiv					0.0730 ***	0.0214
abs_custco					0.0120	0.0181
abs_suppco					-0.0505 ***	0.0149
abs_compco					-0.0001	0.0160
abs_scprco					0.0043	0.0175
abs_scpuco					-0.0015	0.0151
abs_stakediv					0.0040	0.0504
Industry dummies	Yes		Yes		Yes	
pseudo R2	0.103		0.118		0.127	
Log likelihood	1294.6		1316.7		1328.3	
Chi-squared	158.76		180.99		191.72	
observations	1807		1807		1807	

** p < 0.10, ** p < 0.05, *** p < 0.01*

The results for the interval regression model for the first measure of innovation intensity, based on the ratio between R&D expenditure and total sales, is provided in

Table 7-2. Also the models were run through stepwise selection for which the results can be found in Appendix F. For these interval regressions the dependent variable was slightly modified, because there were some unexpectedly high values observed that might influence the regression too much. A recent study on R&D expenditure found that the average R&D expenditure to total sales ratio for the top EU companies was found to be 2.9 % (EuropeanCommission 2006). This study also suggested that a percentage of over 20% is already very high, where in the CIS data sample values of over 1000% were found. Therefore based on the assumption that values of over 0.5 (= 50%) for innovation intensity are unlikely exceptions, observations above this value will be set at 0.5 and will be treated in the interval regression model as an upper limit. This way the high values will not have a disproportional influence on the regression and are still correctly represented in the model.

According to the results of the most basic model (1a), only containing the cooperation variables and the control variables, there is a strongly significant and positive relation between geographic diversity and innovation intensity. Which supports hypothesis 7a that predicts exactly such a relation. Furthermore a weakly significant, negative relation is established between customer cooperation and innovation intensity. However, no hypothesis was formed on the effect of customer cooperation on innovation intensity, because it was expected that such a relation would not be present. Alternative explanations for this will be provided in the discussion. For the other cooperation variables no significant relations towards innovation intensity were observed. Therefore no support is provided for hypotheses 2a, 4a, 5a and 6a which predict positive effects on innovation intensity from cooperating with suppliers, private science partners, public science partner and diverse stakeholder types. Also no support is provided for hypothesis 3a which predicts negative effects from cooperating with competitors on innovation intensity. However, when applying stepwise selection in the interval regression, a significant, positive relation is found between public science partner cooperation and innovation intensity. This supports hypothesis 5a, that predicts such a relation.

Introducing absorptive capacity into the model (1b) substantially increases the goodness of fit of the regression model, but apparently absorbs the significant effect of customer cooperation innovation intensity which no longer seems to be present in this model. However, in the stepwise interval regression model this effect is still present. Absorptive capacity seems to have a very strongly positive and significant

relation towards innovation intensity. This is not surprising, since the indicator for absorptive capacity applied in the model is a continuous effort of internal R&D. This is logically related to innovation intensity, since innovation intensive organizations will in general be continuously engaged in internal R&D.

When analyzing the model (1c) where the product terms are included, a significant positive interaction effect is found between geographic diversity and absorptive capacity. Apparently absorptive capacity strengthens the significant positive effect of geographic diversity on innovation intensity found earlier. This supports hypothesis 8 on the intensifying effect of absorptive capacity on the effects of cooperation on innovation. Also a significant, negative interaction effect is found between supplier cooperation and innovation intensity. This suggests that absorptive capacity has a negative effect on supplier cooperation for which no significant relation was found in earlier models. Since supplier cooperation itself did not provide any significant effect this result is hard to interpret.

Other interesting findings to note are the significant, negative effects of organization size and belonging to a foreign multinational on innovation intensity. This is in line with the general theoretical conception that small firms are more active in innovating (Acs and Audretsch 1988).

Innovation intensity 2

The results for the interval regression model for the second measure of innovation intensity, based on the ratio between R&D personnel in FTE and total personnel in FTE, are presented in Table 7-3. Also the models were run through stepwise selection for which the results can be found in Appendix F. Like was the case for innovation intensity 1, exceptional high values were observed for innovation intensity 2. Where logically an organization can not have more R&D personnel than it has personnel in total, values of over 1 for innovation intensity 2 are actually not possible. Nevertheless such values were indeed observed, probably the result of a mismatch in the scale of reporting between R&D personnel en personnel in total. Because I argue that similar mismatches are likely to be present vice versa which lead to incorrect low values I did not remove the high valued observations from the data set assuming these errors cancel each other out. Nevertheless to reduce the influence of these high values I introduced a limit to the observations in similar fashion to what was done for

innovation intensity 1. Since a value of 1, in which all personnel is R&D personnel, is the logical maximum, I have chosen this value as an upper limit. Therefore observations above this value of 1 will be set at 1 and will be treated in the interval regression model as an upper limit.

Table 7-3 Interval regression results with dependent variable innovation intensity 2

	Model 2a		Model 2b		Model 2c	
Independent variables	**Coeff.**	**Robust S.E.**	**Coeff.**	**Robust S.E.**	**Coeff.**	**Robust S.E.**
geodiversity	0.1162***	0.0162	0.1071***	0.0157	0.0568**	0.0226
custcoop	-0.0061	0.0113	-0.0056	0.0111	-0.0332**	0.0148
suppcoop	-0.0336***	0.0101	-0.0316***	0.0099	-0.0128	0.0129
compcoop	0.0011	0.0117	0.0035	0.0116	-0.0063	0.0148
scprcoop	-0.0023	0.0122	-0.0006	0.0120	-0.0045	0.0170
scpucoop	0.0165	0.0109	0.0150	0.0107	0.0016	0.0154
stakediversity	0.0284	0.0334	0.0201	0.0329	0.0644	0.0430
logemp2004	-0.0575***	0.0094	-0.0612***	0.0094	-0.0615***	0.0094
foreignmult	-0.0007	0.0072	-0.0009	0.0071	0.0001	0.0072
group	-0.0602	0.0480	-0.0669	0.0480	-0.0653	0.0480
abscap			0.0550***	0.0073	0.0516***	0.0104
abs_geodiv					0.0614**	0.0280
abs_custco					0.0332*	0.0200
abs_suppco					-0.0241	0.0182
abs_compco					0.0116	0.0201
abs_scprco					0.0042	0.0221
abs_scpuco					0.0153	0.0208
abs_stakediv					-0.0514	0.0605
Industry dummies	Yes		Yes		Yes	
pseudo R2	0.164		0.188		0.192	
Log likelihood	719.58		743.82		746.48	
Chi-squared	191.8		230.58		238.52	
observations	1407		1407		1407	

** p < 0.10, ** p < 0.05, *** p < 0.01*

According to the results of the most basic model (2a), containing only the cooperation variables and the control variables, again a strongly significant and positive relation between geographic diversity and innovation intensity is found. This supports hypothesis 7a that predicts such a relation. Also a strongly significant and negative relation was established between supplier cooperation and innovation intensity. This is completely opposite from hypothesis 2a which predicts a positive relation between supplier cooperation and innovation intensity. Explanations for this will be provided in the discussion. For the other cooperation variables no significant relations towards innovation intensity were observed. This means no support was

provided for hypotheses 4a, 5a and 6a, which predict positive effects on innovation intensity from cooperating with private science partners, public science partners and diverse stakeholder types. Also no support is provided for hypothesis 3a which predicts negative effects from cooperating with competitors on innovation intensity. However, similarly to the models on innovation intensity 1, the stepwise interval regressions do show a strongly significant effect of public science partners on innovation intensity. This supports hypothesis 5a, that predicts such a relation.

Introducing absorptive capacity into the model (2b) greatly increases the goodness of fit of the regression model, but does not effect any of the significant effects on innovation intensity 2. Again absorptive capacity itself seems to have a very strongly positive and significant relation towards innovation intensity, which as argued earlier is not surprising due to the nature of the indicator.

When analyzing the model (1c) where the product terms are included, again a significant positive interaction effect is found between geographic diversity and absorptive capacity. This supports the earlier observation that absorptive capacity strengthens the significant positive effect of geographic diversity on innovation intensity found earlier. This supports hypothesis 8 on the intensifying effect of absorptive capacity on the effects of cooperation on innovation. Furthermore a significant, positive interaction effect was found between customer cooperation and innovation intensity. This suggests that absorptive capacity has a positive effect on customer cooperation for which no significant relation was found in earlier models. Since customer cooperation itself did not provide any significant effect this result is hard to interpret. Also a significant, negative interaction effect is found in the stepwise interval regression models between supplier cooperation and innovation intensity, which does not show up in the complete model 2c. This effect suggests that absorptive capacity intensifies the significant, negative effect that was found in models 2a and 2b. This supports hypothesis 8 on the intensifying effect of absorptive capacity on the effects of cooperation on innovation.

Finally, like in the model on innovation intensity 1, negative effects of organization size on innovation intensity were found. Which again supports the general belief that small firms are more active in innovating.

Comparison and overall result

Both models based on a different indicator for innovation intensity found a strong significant, positive relation between geographic diversity of partners and innovation intensity, strongly supporting hypothesis 7a. Furthermore both models seem to corroborate with each other on not providing empirical evidence to support any of the hypotheses 3a, 4a and 6a. Also no evidence was found to support hypothesis 2a about the positive effect of supplier cooperation, where the latter model even established a highly significant negative relation. Furthermore in both models some support is provided for hypothesis 5a. Unexpected was the (weakly) significant relation that was found between customer cooperation and innovation intensity 1, as will be explained in the discussion. All and all the models produced strongly similar results.

Also both models seem to agree that there is a strongly significant, positive relation between absorptive capacity and innovation intensity and that it is likely that there is some moderating effect of absorptive capacity on the relations between cooperation and innovation intensity. Although it should be noted that for both models the introduction only slightly increased the goodness of fit of the models, suggesting that the effect of the interaction with absorptive capacity is not very determinative or powerful.

7.2.3. Innovation success

The concept and measurement of innovation (commercial) success as it is applied in the statistical model(s) is fairly novel. In earlier chapters it was explained that in essence the ratio between innovation inputs, in this case R&D expenditure, and outputs, in this case innovative sales, is applied as a measure of innovation success. The result from the models built on this are presented in Table 7-4. Also the models were run through stepwise selection for which the results can be found in Appendix F.

The first thing to notice for the model(s) on innovation success is that the goodness of fit for the model is a lot lower than it was for innovation intensity. This could suggest that the selected variables, and thus also cooperation, are not very decisive in explaining innovation success and that other mechanisms are more important here. For instance marketing, which is undoubtedly important for innovation success, is largely supported by pricing and reputation and only limitedly by cooperation (Mohr, Sengupta et al. 2005). Nevertheless, an alternative explanation

could be that the measurement for innovation success as it is provided here does not give a clear and (scientifically) solid representation of innovation success. This is not highly unlikely, since a measure for innovation success as it is presented here is fairly new and experimental. This issue will be continued further on in the discussion.

Table 7-4 Interval regression results with dependent variable innovation success

	Model 3a		Model 3b		Model 3c	
Independent variables	**Coeff.**	**Robust S.E.**	**Coeff.**	**Robust S.E.**	**Coeff.**	**Robust S.E.**
geodiversity	0.2117	0.2038	0.2002	0.2046	0.8271 *	0.4542
custcoop	0.4367 ***	0.1244	0.4390 ***	0.1247	0.7693 ***	0.2745
suppcoop	-0.2298 *	0.1176	-0.2271 *	0.1176	-0.4326 *	0.2247
compcoop	0.1916 *	0.1159	0.1928 *	0.1157	0.3267	0.2932
scprcoop	-0.0672	0.1246	-0.0670	0.1247	0.3325	0.2940
scpucoop	-0.0735	0.1474	-0.0777	0.1469	-0.3981	0.3345
stakediversity	-0.1784	0.3567	-0.1872	0.3573	-0.4874	0.7165
logemp2004	0.1385 **	0.0650	0.1355 **	0.0651	0.1336 **	0.0643
foreignmult	-0.0178	0.0756	-0.0170	0.0755	-0.0354	0.0747
group	0.2277	0.2684	0.2206	0.2692	0.1813	0.2723
abscap			0.0551	0.0833	0.1875 *	0.1086
abs_geodiv					-0.9031 *	0.5015
abs_custco					-0.4189	0.2996
abs_suppco					0.3152	0.2618
abs_compco					-0.1602	0.3136
abs_scprco					-0.5346 *	0.3236
abs_scpuco					0.5283	0.3629
abs_stakediv					0.2359	0.8158
Industry dummies	Yes		Yes		Yes	
pseudo R2	0.044		0.044		0.052	
Log likelihood	-2496		-2495		-2485	
Chi-squared	82.03		83.96		91.12	
observations	1581		1581		1581	

** p < 0.10, ** p < 0.05, *** p < 0.01*

The results from the most basic model (3a), only containing the cooperation variables and the control variables, indicate a strongly significant and positive relation between customer cooperation and innovation success. This strongly supports hypothesis 1a, but also the general notion that cooperating with customers and identifying their needs is important in bringing innovation to the market. Also a weakly significant positive relation was found for competitor cooperation and innovation success. This is in support of hypothesis 3b. Another weakly significant

relation is observed for supplier cooperation and innovation success, but this is a negative relation. Again, this is completely opposite of what was hypothesized (2b) for supplier cooperation and innovation success similarly to results for supplier cooperation and innovation intensity. Al this will be discussed in the discussion chapter. For hypotheses 5b, 6b and 7b no supporting evidence was provided from the analysis. Where cooperation with public science partners was expected to have a positive effect on innovation success, no significant effect was measured. Also stakeholder type and geographic diversity were expected to have a negative impact on innovation success, but no significant effect was noticed.

This time when introducing absorptive capacity into the model (3b), practically nothing changes and absorptive capacity itself is shown to have no significant relation to innovation success. This is an interesting notion, because it suggests that continuous internal R&D practices and the learning capabilities that come with it have no influence on the commercial success of innovations that are developed. Which could suggest that innovation success is more dependent on successful marketing rather than (successful) development. Also this explains the difference between measuring innovation from input variables and output variables (Acs and Audretsch 1988; Kleinknecht, van Montfort et al. 2002). Thus it is also in support of my approach of measuring innovation intensity and innovation success separately.

Introducing the product terms into the model (3c) in this case barely produces any significant interaction effects. Also the weak significant effects that were found, were not in line with the hypothesis on absorptive capacity. This could be explained through the assumption that market knowledge, which was argued to be the most important type of knowledge for innovation success, is usually less complex in nature than technological knowledge which was supposed to be the driver for innovation intensity and novelty. If market knowledge is indeed less complex, not much absorptive capacity is required to understand and apply the (market) knowledge that becomes available from cooperation. Thus no (significant) interaction effect is present between cooperation and absorptive capacity for innovation success. Another explanation is the fact that the measure applied for absorptive capacity is based on (continuous) internal R&D, which logically produces absorptive capacity for understanding research oriented, technical knowledge, but not directly for understanding and applying market oriented knowledge.

Interesting to note as well is the positive and significant relation between organization size and innovation success, where there was a negative relation between organization size and innovation intensity. This suggests that smaller organizations are more innovation intense, but larger companies excel at creating value from innovation. This is not very unexpected since large organizations have large marketing departments & budgets and a strong brand name. All and all this leads to an interesting question whether cooperation on innovation between small and large organizations provides extra benefits due to the complimentary skills in the innovation process, research vs marketing.

7.2.4. Innovation novelty

As was explained earlier, the ambiguous concept of innovation novelty is measured solely on basis of the newness to the market. Although this neglects the technological aspect of innovation novelty, it is a strong enough measure to analyze certain relevant effects in general on innovation novelty. As was explained in chapter 6, two separate models were developed, where in the first model innovation novelty is solely represented by the ratio between sales of innovative products truly new to the market and sales of all innovative products, including products only new to the organization. In the second model this concept of innovation novelty is extended by integrating the ratio of sales from products new to the market in comparison to the total sales. The two models will be discussed separately after which some comparison will occur.

Innovation novelty 1

The results for the regression models on innovation novelty 1 are presented in Table 7-5. Also the models were run through stepwise selection for which the results can be found in Appendix F.

Again, the first thing to notice is the low goodness of fit for the model(s) on innovation novelty 1. Since this will also prove to be the case for the model(s) on innovation novelty 2, the discussion on this subject is postponed to the paragraph on the overall results for both models.

Table 7-5 Interval regression result with dependent variable innovation novelty 1

Independent variables	Model 4a Coeff.	Model 4a Robust S.E.	Model 4b Coeff.	Model 4b Robust S.E.	Model 4c Coeff.	Model 4c Robust S.E.
geodiversity	0.1992	0.1539	0.1497	0.1533	0.3483	0.2900
custcoop	0.2056 **	0.1048	0.2143 **	0.1043	0.2450	0.2066
suppcoop	-0.2305 **	0.0968	-0.2267 **	0.0963	-0.4237 **	0.1670
compcoop	0.0209	0.0898	0.0296	0.0896	-0.0179	0.1767
scprcoop	0.0008	0.1006	-0.0049	0.0997	-0.1588	0.1826
scpucoop	0.1330	0.1044	0.1097	0.1043	0.2154	0.1999
stakediversity	0.1769	0.3023	0.1462	0.3005	0.4181	0.5452
logemp2004	0.0152	0.0515	-0.0026	0.0517	-0.0012	0.0517
foreignmult	0.0674	0.0617	0.0760	0.0614	0.0689	0.0616
group	0.0060	0.2264	-0.0216	0.2282	-0.0197	0.2286
abscap			0.2410 ***	0.0638	0.2373 ***	0.0825
abs_geodiv					-0.2709	0.3309
abs_custco					-0.0436	0.2376
abs_suppco					0.3179	0.2030
abs_compco					0.0820	0.2039
abs_scprco					0.2413	0.2174
abs_scpuco					-0.1250	0.2348
abs_stakediv					-0.4833	0.6545
Industry dummies	Yes		Yes		Yes	
pseudo R2	0.019		0.022		0.022	
Log likelihood	-1881		-1873		-1871	
Chi-squared	89.95		103.73		107.69	
observations	1814		1814		1814	

** p < 0.10, ** p < 0.05, *** p < 0.01*

The results from model 4a, only containing the cooperation variables and the control variables, yielded highly unexpected results. Only significant relations were found for customer cooperation and supplier cooperation. Customer cooperation was found to have a significant, positive effect on innovation novelty, where hypothesis 1b predicted a negative relation. A possible explanation for this important finding is connected to the explanation for the significant positive effect of customer cooperation on innovation intensity and will be discussed in the discussion chapter. Supplier cooperation on the other hand yielded a significant, negative effect on innovation novelty, where no relation was expected. This is likely to also be connected to the unexpected result for supplier cooperation on innovation intensity and innovation success, which will be discussed in the discussion chapter. Furthermore, where hypotheses 3c, 4b, 5c, 6b and 7b predicted significant relations on innovation novelty for cooperation with competitors, private science partners, public

science partners, diverse stakeholders and geographically divers partners, no support is provided from the statistical analysis. However, when analyzing the stepwise interval regression models a strongly significant, positive effect is found for cooperation with public science partners, supporting hypothesis 5c.

Introducing absorptive capacity into the model (4b) slightly increases the goodness of fit of the regression model and does not effect any of the significant effects on innovation novelty 1. Absorptive capacity nevertheless seems to have a very strongly positive and significant relation towards innovation novelty. This is not surprising, since the indicator for absorptive capacity applied in the model is a continuous effort of internal R&D. Where from the demand-pull technology-push debate (Dosi 1982) it was argued that radical innovation often comes from fundamental (internal) research, it is not surprising that a continuous effort in internal R&D leads to more novel innovation.

Introducing the product terms into the model (4c) for innovation novelty 1, yielded practically no significant interaction effects and thus no support can be provided for hypothesis 8, which is fairly unexpected. Where novel innovation intuitively requires new, unfamiliar (technological) knowledge, high absorptive capacity can be expected to be especially important in understanding and applying such complex knowledge. An important explanation here might be the fact that innovation novelty is solely measured through newness to the market as opposed to technological newness. Technologically completely new products can be expected to be new to the market as well, whereas products new to the market are not necessarily technologically new. By measuring innovation novelty solely on market novelty thus a bias is created, as will be discussed further in the following chapters. Because market oriented knowledge can often lead to innovations new to the market, but which are not technologically new, the effect of market knowledge on innovation novelty might be overestimated. Since market oriented knowledge, as was explained with the results for innovation success, is not expected to require high absorptive capacity this might explain the results. Another explanation is simply that interaction effects between absorptive capacity and cooperation is present for incremental innovation as well as radical innovation, cancelling each other out.

Innovation novelty 2

The results for the regression models on innovation novelty 2 are presented in Table 7-6. Also the models were run through stepwise selection for which the results can be found in Appendix F. Important to note for this model is that integrating the ratio of sales from products new to the market in comparison to the total sales into the measure, might lead to the unexpected effect of also partly measuring overall innovation performance, and thus both elements of innovation intensity and innovation success.

Table 7-6 Interval regression result with dependent variable innovation novelty 2

	Model 4a"		Model 4b"		Model 4c"	
Independent variables	**Coeff.**	**Robust S.E.**	**Coeff.**	**Robust S.E.**	**Coeff.**	**Robust S.E.**
geodiversity	0.0644 **	0.0319	0.0502 *	0.0318	0.0554	0.0656
custcoop	0.0380 *	0.0213	0.0408 *	0.0214	0.0363	0.0454
suppcoop	-0.0449 **	0.0185	-0.0443 **	0.0185	-0.0415	0.0325
compcoop	0.0239	0.0178	0.0262	0.0177	-0.0235	0.0314
scprcoop	-0.0121	0.0194	-0.0142	0.0192	-0.0117	0.0316
scpucoop	0.0413 *	0.0225	0.0347	0.0223	0.0379	0.0344
stakediversity	0.0181	0.0594	0.0104	0.0592	0.0366	0.1079
logemp2004	-0.0256 ***	0.0096	-0.0309 ***	0.0097	-0.0311 ***	0.0097
foreignmult	0.0128	0.0123	0.0157	0.0122	0.0160	0.0122
group	0.0221	0.0432	0.0133	0.0431	0.0128	0.0427
abscap			0.0699 ***	0.0129	0.0687 ***	0.0169
abs_geodiv					-0.0096	0.0717
abs_custco					0.0056	0.0507
abs_suppco					-0.0034	0.0387
abs_compco					0.0704 *	0.0382
abs_scprco					-0.0069	0.0398
abs_scpuco					-0.0068	0.0447
abs_stakediv					-0.0276	0.1300
geodiversity	0.0644 **	0.0319	0.0502 *	0.0318	0.0554	0.0656
Industry dummies	Yes		Yes		Yes	
pseudo R2	0.043		0.053		0.054	
Log likelihood	-436.4		-420.8		-419.2	
Chi-squared	103.75		117.82		120.93	
observations	1814		1814		1814	

** p < 0.10, ** p < 0.05, *** p < 0.01*

As was mentioned earlier, the goodness of fit of the model(s), although higher than for innovation novelty 1, is still fairly low as will be discussed later on.

The results from model 5a, only containing the cooperation variables and the control variables, indicate a significant, positive relation between geographic diversity and innovation novelty. This result supports hypothesis 7c. A weakly significant positive relation was also observed for cooperation with public science partners and

innovation novelty. This result is in support of hypothesis 5c. However, there were also some highly unexpected results. Like for innovation novelty 1, the analysis showed a significant, positive relation between customer cooperation and innovation novelty, which is completely opposite from what is being claimed in hypothesis 1b. As mentioned this will be discussed in further chapters. Also again a significant negative relation was observed between supplier cooperation and innovation novelty, where no relation was expected. Finally, where according to hypotheses 3c and 4b cooperation with competitors and/or private science partners should show a significant positive relation to innovation novelty, no significant effects were observed.

The introduction of absorptive capacity in the model had a reasonable effect on the goodness-of fit of the model. This also resulted in the weakly significant relation between public science partner cooperation and innovation novelty becoming insignificant. Although, in the stepwise model a significant effect was still observed. Absorptive capacity itself was found to have a highly significant positive relation to innovation novelty, which is not extremely surprising due to the nature of the measure for absorptive capacity as was explained for the results of innovation novelty 1.

Also similarly to the model on innovation novelty 1, introducing the product terms into the model (4c) for innovation novelty 2, yielded practically no significant interaction effects and thus no support can be provided for hypothesis 8, which is fairly unexpected. An explanation has been provided with the results for innovation novelty 1.

Finally, also interesting to mention is the highly significant, negative effect of organization size on innovation novelty 2, which was not found with the results for innovation novelty 2. This negative effect of organization size is in line with the large acception that small (flexible) organizations produce more radical innovation than large incumbent organizations (Ettlie and Rubenstein 1987), although this is under debate (Chandy and Tellis 2000).

Comparison and overall result

Both models based on a slightly different indicators for innovation novelty found a strongly significant, positive relation between customer cooperation and innovation novelty, strongly rejecting hypothesis 1b. Also both models seem to corroborate with

each other that supplier cooperation has a strongly significant, negative relation on innovation novelty, where no effect was expected. Additionally, the models both found results that partially indicate a significant, positive relation between public science partner cooperation and innovation novelty, supporting hypothesis 5c. Furthermore, the model for innovation intensity 2 observed significant, positive relation between geographic diversity of partners and innovation novelty, where the model for innovation novelty 1 found none. This partially supports hypothesis 7b.

Also both models seem to agree that there is a strongly significant, positive relation between absorptive capacity and innovation novelty, but found no proof for any moderating effect of absorptive capacity on the relations between cooperation and innovation intensity.

8. Discussion and conclusions

This chapter will provide some (theoretical) reflection on the results from the empirical analysis as it was provided in the previous chapter. Also in this chapter the limitations of the research will be discussed and some relevant recommendations will be provided.

8.1. Summary of results and theoretical reflection

A global summary of the overall results of the empirical analysis in relation to the research hypotheses is provided in Table 8-1. This also includes some important significant result for which no hypotheses were derived from the theory. Where the different types of (R&D) cooperation partners were observed to have different effects on innovation, the general conclusion can fairly safely be drawn that partner characteristics matter for innovation. More detail about the results found and the implications will be discussed in the remainder of this chapter.

One of the main findings was that customer cooperation seems to have a positive effect on all the aspects of innovation as they were conceptualized for this research. Where a positive effect on innovation success was expected, the positive effect on innovation intensity and especially the positive effect on innovation novelty were not. One explanation might be provided by von Hippel who argued that certain customers or users, which are well ahead of market trends and have needs that go far beyond those of the average user, are an important source for generating breakthrough ideas and innovation (von Hippel 1986; Mohr, Sengupta et al. 2005; Tidd, Bessant et al. 2005). These 'lead users' are even expected to be capable of developing innovations themselves. As such the knowledge that these type of customers represent is more technological and complex in nature than would be expected from average customers. Thus, cooperation with lead users can be expected to have a positive influence on innovation intensity and the novelty of innovation according to the knowledge based model as it was presented in chapter 5. The typology of customers in general, as it is applied in the CIS surveys and thus also for this research, does not distinguish between lead users and other (regular) customers. This might partially explain the results as they were found in the empirical analysis. Nevertheless, the assumption that customers have a limited mindset on products and thus are mainly important for

incremental innovation (Veryzer 1998; Pittaway, Robertson et al. 2004) is still likely to be faulty or highly exaggerated. All and all this research has found that customers are an important, or probably even thé most important type of cooperation partner for innovation.

Table 8-1 Summary of the results of the emperical analysis in relation to the hypotheses

Hypothesis	Empirical evidence	Alternative relation
Customer cooperation:		
H1a: positive effect on innovation success	strong support	
H1b: negative effect on innovation novelty	rejection	positive relation
Supplier cooperation:		
H2a: positive effect on innovation intensity	rejection	negative relation
H2b: postive effect on innovation success	rejection	negative relation
Competitor cooperation:		
H3a: negative effect on innovation intensity	no support	
H3b: positive effect on innovation success	weak support	
H3c: positive effect on innovation novelty	no support	
Private science partner cooperation:		
H4a: positive effect on innovation intensity	no support	
H4b: positive effect on innovation novelty	no support	
Public science partner cooperation:		
H5a: positive effect on innovation intensity	support	
H5b: positive effect on innovation success	no support	
H5c: positive effect on innovation novelty	support	
Stakeholder diversity:		
H6a: positive effect on innovation intensity	no support	
H6b: negative effect on innovation success	no support	
H6c: positive effect on innovation novelty	no support	
Geographic diversity:		
H7a: positive effect on innovation intensity	strong support	
H7b: negative effect on innovation success	no support	
H7c: positive effect on innovation novelty	partial support	
Absorptive capacity:		
H8: intensifies cooperation effects	Mixed results	Only for innovation intensity
Unexpected results		
Customer cooperation:		
Weakly significant positive effect on innovation intensity		
Supplier cooperation:		
Significant negative effect on innovation novelty		

Another important finding was the fact that supplier cooperation in contrast to customer cooperation seems to have a negative effect on all the aspects of innovation as they were conceptualized for this research. This was highly unexpected, since supplier cooperation is generally accepted as an important driver for innovative performance (Gemünden, Ritter et al. 1996; Ragatz, Handfield et al. 1997; Pittaway, Robertson et al. 2004). However, the unexpected negative effect of cooperation with suppliers can partly be explained. In Figure 7-1 it was shown that supplier cooperation is the most occurring type of cooperation for the organizations in the sample. This led to a suspicion that perhaps supplier cooperation is relatively often the only type of cooperation for organizations. This suspicion was tested and supported by some statistical plots as is shown in Appendix G. Since supplier cooperation indeed is relatively often the only type of cooperation for an organization in comparison to the other types of cooperation, it can be argued that indirectly supplier cooperation also represents organizations having only one type of cooperation. However, this indirect effect should largely be absorbed by the diversity variables in the model. Additionally, the fact that supplier cooperation is the most occurring type of cooperation and relatively often the only type of cooperation suggests that organizations are quick to look at their suppliers first for cooperation in innovation. Organizations without prior cooperation experience can therefore be argued to have their first cooperative agreements with suppliers. More importantly however is that it is not unlikely that organizations jump into cooperation agreements with suppliers without careful consideration and analysis of their situation. This could largely be fed by the earlier mentioned general belief that supplier cooperation is an important driver for innovative performance. I argue that although generally certain effects can be attributed to certain types of cooperation, there is always some dependence on the situation of the organization and its objectives. In the case for supplier cooperation it seems that opportunistic behavior by organizations in selecting their cooperation partners is very likely. This might be a cause of the unexpectedly negative effects that were found for supplier cooperation on innovation. Nevertheless, the observed negative effects of supplier cooperation on innovation are robust and strong enough to opt for a reevaluation of the assumed positive role of suppliers in innovation.

The contrasting effects of customer cooperation and supplier cooperation on innovation also bring an interesting dilemma to the attention. The literature often

assumes similar cooperative roles and effects for customers and suppliers, which is underlined by the fact that cooperation with customers and suppliers is often grouped under the term 'vertical cooperation' as was mentioned in chapter 4. The results for this study suggest that this notion should be revised and that cooperating with suppliers and customers is likely to produce significantly different effects.

On the subject of cooperation with competitors not many significant effects on innovation were observed from the empirical analysis. Although a weakly positive effect was documented for competitor cooperation on innovation success as was hypothesized, this study did not find compelling evidence that competitor cooperation really matters for the aspects of innovation as they were conceptualized for the research.

Similarly, the empirical analysis did not reveal any evidence that cooperation with private science partners matters for the aspects of innovation as they were conceptualized in the research. Better results might have been obtained if it had been possible to make a distinction between consultants and research institutes & labs, which was not possible from the CIS data in its current form. As was argued in chapter 2 on the stakeholder typology, consultants and research institutes are likely to have significantly different roles in the innovation process and therefore should be analyzed separately. Especially the categorization of consultants as science partners is disputable, since consultants are usually more involved in the management and control of the innovation process rather than the (scientific) content (Bessant and Rush 1995).

For cooperation with public science partners however the empirical analysis did show significant relations on certain aspects of innovation. As was hypothesized significant positive relations were established between public science partners and innovation intensity and innovation novelty, which is in line with the findings of previous studies (Kaufmann and Todtling 2001; Miotti and Sachwald 2003; Belderbos, Carree et al. 2004). This study however did not find evidence of a significant, positive effect of public science partner cooperation on innovation success as was hypothesized. Nevertheless cooperation with public science partners overall seems to have a positive effect on innovation. Interesting to note here is that for public

science partner cooperation the significant effects were mainly observed in the stepwise interval regression models and barely in the models where all the variables were included. This might suggest some correlation between public science partner cooperation and certain other (insignificant) independent variables in the model. For instance it could very well be the case that cooperation with public science partners is more common in certain industries rather than others.

An interesting topic within this study was the investigation of the effect of diversity of cooperation partners on innovation. The empirical results showed that geographic diversity of partners had some significant positive effects on innovation, where stakeholder diversity did not yield any significant effects. More precisely, geographic diversity of partners was found to have a significant positive effect on innovation intensity as well as innovation novelty, as was hypothesized. However, whether this also directly supports the theorized positive effect on innovation of (meaningful) diversity of partners in general is disputable due to measurement limitations and the fact that causality is hard to determine, which will be discussed later on. Also the fact that stakeholder diversity did not yield any significant results leaves many uncertainties surrounding the effects of partner diversity in general. Especially, since stakeholder diversity can indeed be argued to be meaningful due to the differentiated empirical results observed for the stakeholders separately. Nevertheless, the results for this study can at least be argued to provide a suspicion that diversity of partners in cooperation might indeed be relevant for innovation.

Finally, on the effects of absorptive capacity on the relation between cooperation and innovation the empirical analysis found mixed results. For innovation intensity absorptive capacity indeed was shown to significantly intensify the significant cooperation effects. However, for innovation success and innovation novelty no evidence was provided for an intensifying effect of absorptive capacity for any of the significant cooperation effects that were established. An explanation for this was provided with the results based on the assumption that absorptive capacity is mainly relevant in the case of complex, technological knowledge. All and all, the intensifying or moderating effect that was found for absorptive capacity on the relation between cooperation an innovation intensity, suggests that certain organization specific capabilities are important for the effectiveness of cooperation. This could be an

interesting topic for further research, because it suggests that it is possible to develop and improve certain cooperative competencies.

8.2. Research limitations

Like any other research this research has some limitations, which should be documented and discussed for a better understanding of the relevance and robustness of the results. Also, the limitations of the research in its current form might provide incentive for further research on the subject, extending and confirming the results and conclusions from this study.

8.2.1. Data limitations

The available dataset from the CIS surveys was an important driver for the research and provided some nice research possibilities. With the CIS data being collected, examined and cleaned by the Dutch central bureau of statistics (CBS), a high level of reliability could be assumed. Nevertheless the data had some important limitations, of which the four main ones will be discussed.

First off, in constructing the relevant variables for the research it became apparent, that although the CBS did a thorough analysis of the data, some errors still existed in the data as can be expected. Especially for innovation intensity several unlikely or even impossibly high values were observed. For instance, where organizations reported more R&D personnel than they reported personnel in total. Such errors are usually the result of inconsistency in the scales of reporting. As was explained, the 'faulty' observations were not removed from the sample under the assumption that such scale errors are likely to be present both ways, creating extraordinary high ánd low values, and as such might cancel each other out. However, because extraordinary high values have a stronger impact on regressions, their contribution was reduced by introducing upper limits in the data. Another possibility would have been to completely remove possible faulty observations from the sample. However, since incorrectly low values are hard to detect, this cerates the risk of creating a bias. Also there is the risk of removing valid observations from the sample. Both approaches can be expected not to remove all the bias from the data.

Another limitation in the data is the subjective nature of certain questions. An important example here is the distinction between products new to the firm and new

to the market, which was very important in constructing a measure for innovation novelty. Determining whether a product is new to the market or only new to the firm, is very dependent on who is filling out the survey or even the state of mind of that person. For instance a head of marketing in a good mood is probably more likely to categorize a certain product as new to the market than an agitated head of research is. Some bias will always be present for these type of questions and can only be assumed to be spread normally throughout the sample.

Furthermore, although the data nicely seems to fit the subject of the study, it was not tailor made for the research and as such had some significant content limitations. The most evident was the fact that all cooperation measures in the data were represented by dummies, only denoting a certain type of cooperation en absolutely no information on the amount of cooperation agreements. Therefore in the statistical analysis, cooperation with one customer is regarded to be the same as cooperation with dozens of customers, which makes it impossible to make relevant inference on the strength of the relationship. The dummy representation also led to some strong limitations for the measurement of the diversity indices, as will be further explained in the next paragraph on measurement limitations.

Finally, there is the huge mismatch between the samples of the different CIS datasets, making it very hard to integrate longitudinal data into the analysis without greatly compromising the sample size of the data. This had a huge effect, mainly for the construction of the innovation success measure as will be discussed in the next paragraph on measurement limitations.

8.2.2. Measurement limitations

Mainly due to the data limitations as they were discussed above, some rough assumptions had to be made in constructing several important variables. This in combination with the fact that the construction of most of these variables was fairly novel and as such not yet established, makes the validity of these variables disputable.

First off, there is the measurement of innovation success, which theoretically seems to be quite solid. A return on investment like measure for innovation seems a logical measure of innovation success. However, some rough assumptions had to be made in the construction of this variable. Firstly, there is the issue that it is hard to estimate the time lag between R&D investment and sales of new products. It was

possible to make an estimate for this based on the literature, but it is still very likely that this lag time strongly differs per organization and even per product. Secondly, because of the mismatch between the different CIS datasets, data on R&D expenditure of previous years was only available for a limited part of the sample. This was solved by making the very rough assumption that R&D expenditure in general is fairly stable over the years and thus can be argued to be similar to the current R&D expenditure where observations were missing. Finally, there is the fact that determining innovative sales is very subjective, because the respondents might have completely different perspectives on which products are innovative and which are not. This is underlined in the huge spread of values that was observed for innovation success. Organizations that barely reported any R&D expenditure, did report many innovative sales and vice versa. This eventually led to the necessity of a non-linear transformation of the innovation success measure. All and all, it can be assumed that the measure for innovation success, although theoretically sound, only provides a fairly rough indication for innovation success. This might also explain the low goodness of fit of the innovation success model in comparison to the models for innovation intensity, which are based on measures that are often applied in the literature and were calculated on the basis of reliable data.

Secondly, there are the measures for innovation novelty. These measures lack an important theoretical component in the sense that novelty here is only based on the market novelty and not technological novelty. This was the result from a lack of content in the CIS data set, which did not provide any information on the technological newness of (product) innovations. Furthermore, the measures of innovation novelty are very sensitive to the subjectiveness of respondents in determining newness to the market etc. Also there is a strong suspicion that the percentages of sales from products new to the market and new to the firm are very rough estimates anyway since it is likely that organizations do not have very detailed financial figures on this subject. All this makes the applied measures very rough indicators for true innovation novelty. Similarly to innovation success, this might also explain the low goodness of fit of the innovation novelty models in comparison to the models for innovation intensity, which are based on measures that are often applied in the literature and were calculated on the basis of reliable data

Although the fairly novel measures for innovation success and innovation novelty are expected to have some validity issues as was discussed above, their introduction

did prove to be valuable for the research. The statistical analysis for the different dependent variables of innovation intensity, innovation success and innovation novelty yielded significantly different results in line with what could be expected. This provided more insight and confirmation on the mechanisms behind the relations between cooperation and innovation. This strengthened my opinion that a unilateral approach to the measurement of innovation is outdated with the current level of research and literature in the field. The innovation process is generally accepted to be a highly complex, phase dependent process for which the performance can and should not be measured unilaterally. The multidimensional approach as it was applied in this study provided many interesting insights and possibilities in analyzing the relations between cooperation and innovation.

Finally, were also some strong limitations to the measurement of the diversity of partners as it was applied in the research. Although diversity measurement is an established topic in which the Simpson's index is an conventional method to calculate diversity, the method of application of the index in this study is disputable. Where the dummy variables on cooperation as explained do not represent amounts, the diversity indices calculated from these dummies can not provide an accurate indication for diversity. As such the diversity indices here can only indicate a reasonable suspicion of diversity. To actually establish diversity of partners, more information is required on the amount of cooperation agreements. Also, it is hard to determine whether and to what extend measuring the (geographic) diversity of partners truly indicates a diversity of knowledge and resources of partners, or mainly indicates other organizational characteristics like the international orientation of an organization.

8.2.3. Causality

The study was mainly based on the most recent version of the CIS survey, only limitedly utilizing data from earlier CIS datasets. As such the empirical analysis for this research is cross-sectional. For cross-sectional studies, causality is very hard or even impossible to determine, which is unfortunate since the causality for many of the relations that are investigated in this study is not apparent in advance. Especially in the case of (geographic) diversity, the positive relations that were found between geographic diversity and innovation can be argued to work both ways. Geographic diversity was hypothesized to lead to a diverse knowledge base and as such lead to

greater potential for (radical) innovation. However, it could just as well be argued that a large effort in developing (radical) innovation might lead organizations to pursue new ideas and technologies abroad, leading to a more geographically diverse set of cooperation partners. Similarly, on the general subject of cooperation it can be argued that cooperation does not lead to innovation, but innovation leads to cooperation (Koschatzky 1999). The lack of causality is therefore an important issue to consider in evaluating the results for this research.

8.3. Implications and recommendations

This study has produced some interesting insights on the relation between cooperation and innovation. This chapter will discuss the managerial implications and recommendations that follow from these insights.

8.3.1. Managerial implications

The most general insight that was provided from the research was that partner characteristics in (R&D) cooperation indeed matter for innovation. The empirical results to a large extend supported this notion in the sense that for different types and characteristics of cooperation partners different effects on innovation were observed. This suggests that the choice for cooperation partners in innovation is far from trivial. From this I argue that Innovation managers should be aware of the different effects of certain types of cooperation and align them with the objectives and settings of innovation projects. As such this study joins a growing movement in the field of cooperation stressing the need for cooperation portfolio management. This is strengthened by an additional finding that at present opportunistic behavior in the selection of cooperation partners is likely to be general practice due to a high concentration on suppliers as cooperation partners. Pioneering in setting up cooperation portfolio's, could therefore very well lead to a significant competitive advantage on the average competition.

Another important finding was that the general consensus that integrating suppliers in the innovation process is a necessary and highly beneficial strategy, should be rethought. Where supplier cooperation was shown to mainly have detrimental effects on innovation, managers should perhaps start looking in different

directions for help in the innovation process. Where cooperation with customers or public science partners seem to be beneficial for certain aspects of innovation, these types of partners are perhaps a better starting point for cooperating in innovation. Also, from the positive effects found for geographic diversity of partners on innovation, it can be advised that in the search for the best cooperation partners it is wise not to limit the search within borders.

Finally, this study found evidence that absorptive capacity can intensify the effects of cooperation in certain cases. This suggests that the ability to create value from cooperation is partly an organizational skill that can be improved. Organizations should be aware of their own cooperative abilities and constantly be in pursuit of improvements in these abilities. Practically, this could be realized through documentation and assessment of cooperative activity, setting up cooperation guidelines and infrastructure, and education of personnel on cooperative skills.

8.3.2. Recommendations for further research

The results and limitations of this research provide a strong basis for further research on the relation between cooperation and innovation. This chapter briefly discusses some recommendations for future research that can be drawn from this study.

As was mentioned it was not possible for this study to determine causality for the relations found between cooperation and innovation, due to the cross-sectional nature of the empirical analysis. Further research based on longitudinal data is recommended to establish this causality and develop awareness of any trends and changes in the relations over the years.

One of the research's main findings was the strong difference in effects on innovation for cooperation with customers and suppliers. This finding could potentially have a huge impact on current theory and practice in cooperation. The difference in cooperation effects for customers and suppliers should therefore be extensively studied for confirmation. Also it should be investigated, when the difference in effect of cooperation with customers and supplier is indeed confirmed, what the mechanisms are behind the differences in effects on innovation

The study found mixed results on the effect of absorptive capacity on innovation. To confirm and better understand the mechanisms behind the interaction between

absorptive capacity and cooperation more research is required on the subject. This is an important topic, because the interaction between absorptive capacity and cooperation suggests that the success or value of cooperation is largely determined by organization specific competencies. Further research identifying and explaining such cooperative competencies, could potentially have a strong influence on the current practice and effectiveness of cooperation agreements.

As was discussed in the measurement limitations, the methodology for the analysis of the diversity of partners for this research were very crude, which makes the results hard to interpret. Therefore, from this study only a reasonable suspicion can be provided that (geographic) diversity of partners matters in cooperation. As such diversity in cooperation is an aspect that deserves more attention and should be investigated more thoroughly and accurately than was possible from the CIS data in this study. The research on diversity of partners could also be extended by researching new types of diversity, like diversity of partner size or industry etc.

The multidimensional approach towards the measurement of innovation as it was applied in this research was found to be valuable and provided new insights on the subject. For further research in the field of innovation it would be recommended to evaluate and improve the multidimensional measurement of innovation as it was applied for this research.

In this study the relationships between cooperation and innovation was analyzed on actor level. An interesting extension of this research would be to analyze inter-organizational cooperation and innovation on a dyadic or even network level. However, this would require cooperation data of much higher detail and complexity than the CIS data currently provides.

8.3.3. Recommendations for CIS survey

As became apparent from the chapter on data limitations, there were some important issues with the CIS data that strongly hampered the validity of the research. For further versions of the CIS data, therefore I would like to make some recommendations.

First, there is the issue with the dummy variables for cooperation, which is a very limited representation of the data. If it would have been possible to get an indication of the amount of cooperation agreements for each type of cooperation partner, the

validity of the results could have been much higher. Also relevant conclusions could be drawn on the strength of the relationship, which is not possible for this research based on cooperation dummies. Moreover, the Simpson's diversity index would also provide a much better and reliable measure for diversity if information on the amounts of cooperation agreements were present.

Secondly, there were some issues with constructing a valid measure for innovation novelty, largely because no data was present in the CIS dataset on the technological newness of products. Market newness and technological newness are both required to construct a theoretically sound measure for innovation novelty. Therefore, for the coming versions of the CIS survey it is recommended to include some questions to determine the technological newness of products.

Finally, there is the typology of cooperation partners that is applied in the CIS surveys. This typology lacks a level of detail that allows for an accurate investigation of the effects between certain types of cooperation partners and innovation. The CIS typology does not distinguish between consultants and research institutes, between lead users and ordinary customers, between buyers and distributors and between competitors and non-competitive organizations in the same sector. As such the typology applied in the CIS survey should be reevaluated and extended for further versions of the CIS survey.

References

Acs, Z. J. and D. B. Audretsch (1988). "Innovation in Large and Small Firms: An Empirical Analysis." American Economic Review **78**(4): 678-90.

Acs, Z. J. and D. B. Audretsch (1990). Innovation and small firms. Cambridge, MIT press.

Atallah, G. (2002). "Vertical R&D Spillovers, Cooperation, Market Structure, and Innovation." Economics of Innovation and New Technology **11**(3): 179 - 209.

Atuahene-Gima, K. (1996). "Market orientation and innovation." Journal of Business Research **35**(2): 93-103.

Barney, J. (1991). "FIRM RESOURCES AND SUSTAINED COMPETITIVE ADVANTAGE." Journal of Management **17**(1): 99-120.

Barney, J., M. Wright, et al. (2001). "The resource-based view of the firm: Ten years after 1991." Journal of Management **27**(6): 625-641.

Baum, J. A. C., T. Calabrese, et al. (2000). "Don't go it alone: Alliance network composition and startups' performance in Canadian biotechnology." Strategic Management Journal **21**(3): 267-294.

Baumol, W. J. (1992). "HORIZONTAL COLLUSION AND INNOVATION." Economic Journal **102**(410): 129-137.

Belderbos, R., M. Carree, et al. (2004). "Heterogeneity in R&D cooperation strategies." International Journal of Industrial Organization **22**(8-9): 1237-1263.

Belderbos, R., M. Carree, et al. (2004). "Cooperative R&D and firm performance." Research Policy **33**(10): 1477-1492.

Belderbos, R., M. Carree, et al. (2006). "Complementarity in R&D cooperation strategies." Review of Industrial Organization **28**(4): 401-426.

Bessant, J. and H. Rush (1995). "Building bridges for innovation: the role of consultants in technology transfer." Research Policy **24**(1): 97-114.

Boer, H. and W. E. During (2001). "Innovation, what innovation? A comparison between product, process and organizational innovation." International Journal of Technology Management **22**(1-3): 83-107.

Borgatti, S. P. and P. C. Foster (2003). "The network paradigm in organizational research: A review and typology." Journal of Management **29**(6): 991-1013.

Boschma, R. A. (2005). "Proximity and innovation: A critical assessment." Regional Studies **39**(1): 61-74.

Burt, R. (1995). Structural Holes: The Social Structure of Competition, Harvard University Press.

Burt, R. S. (2000). The network structure of social capital. Research in Organizational Behavior, Vol 22, 2000. **22:** 345-423.

Cassiman, B. and R. Veugelers (2002). "R&D cooperation and spillovers: Some empirical evidence from Belgium." American Economic Review **92**(4): 1169-1184.

Chandy, R. K. and G. J. Tellis (2000). "The Incumbent's Curse? Incumbency, Size, and Radical Product Innovation." Journal of Marketing **64**(3): 1-17.

Chiesa, V. and R. Manzini (1998). "Organizing for technological collaborations: a managerial perspective." R & D Management **28**(3): 199-212.

Cohen, W. M. and D. A. Levinthal (1990). "ABSORPTIVE-CAPACITY - A NEW PERSPECTIVE ON LEARNING AND INNOVATION." Administrative Science Quarterly **35**(1): 128-152.

Combs, J. G. and J. David J. Ketchen (1999). "Explaining interfirm cooperation and performance: toward a reconciliation of predictions from the resource-based view and organizational economics." Strategic Management Journal **20**(9): 867-888.

Cooke, P. and D. Wills (1999). "Small Firms, Social Capital and the Enhancement of Business Performance Through Innovation Programmes." Small Business Economics **13**(3): 219-234.

Cooper, J. R. (1998). "A multidimensional approach to the adoption of innovation." Management Decision **Volume 36**(Number 8): pp. 493-502(10).

Cooper, R. G. (1979). "DIMENSIONS OF INDUSTRIAL NEW PRODUCT SUCCESS AND FAILURE." Journal of Marketing **43**(3): 93-103.

Cooper, R. G. and E. J. Kleinschmidt (1987). "New Products: What Separates Winners from Losers?" Journal of Product Innovation Management **4**(3): 169-184.

Daft, R. L. (1978). "DUAL-CORE MODEL OF ORGANIZATIONAL INNOVATION." Academy of Management Journal **21**(2): 193-210.

Damanpour, F. (1991). "ORGANIZATIONAL INNOVATION - A METAANALYSIS OF EFFECTS OF DETERMINANTS AND MODERATORS." Academy of Management Journal **34**(3): 555-590.

Das, T. K. and B. S. Teng (2000). "A resource-based theory of strategic alliances." Journal of Management **26**(1): 31-61.

Dewar, R. D. and J. E. Dutton (1986). "The adoption of radical and incremental innovations: an empirical analysis." Manage. Sci. **32**(11): 1422-1433.

Dictionary.com. (2007). Dictionary.com Unabridged (v 1.1) Retrieved June 05, 2007, from http://dictionary.reference.com/browse/cooperation.

Dosi, G. (1982). "Technological paradigms and technological trajectories : A suggested interpretation of the determinants and directions of technical change." Research Policy **11**(3): 147-162.

Dussauge, P., B. Garrette, et al. (2000). "Learning from competing partners: Outcomes and durations of scale and link alliances in Europe, North America and Asia." Strategic Management Journal **21**(2): 99-126.

Duysters, G. and A. P. de Man (2003). "Transitory alliances: an instrument for surviving turbulent industries?" R & D Management **33**(1): 49-58.

Ebersberger, B., K. Laursen, et al. (2005). The Origins of Radicalness and Complexity in Product Innovation: An Analysis of the Finnish Innovation Database. Druid conference: DYNAMICS OF INDUSTRY AND INNOVATION: ORGANIZATIONS, NETWORKS AND SYSTEMS. Copenhagen.

Eisenhardt, K. M. and C. B. Schoonhoven (1996). "Resource-based view of strategic alliance formation: Strategic and social effects in entrepreneurial firms." Organization Science **7**(2): 136-150.

Ettlie, J. E., W. P. Bridges, et al. (1984). "Organization Strategy and Structural Differences for Radical Versus Incremental Innovation." Management Science **Volume 30**(6): pp. 682–695.

Ettlie, J. E. and A. H. Rubenstein (1987). Firm Size and Product Innovation. **4:** 89-108.

Etzkowitz, H. and L. Leydesdorff (2000). "The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations." Research Policy **29**(2): 109-123.

EuropeanCommission (2006). The Analysis of the 2006 EU Industrial R&D Investment Scoreboard. I. f. P. T. S. Directorate General Joint Research Centre.

Eurostat. (2007). "CORDIS Homepage." from http://cordis.europa.eu/innovation-smes/src/cis.htm.

Faems, D., B. Van Looy, et al. (2005). "Interorganizational collaboration and innovation: Toward a portfolio approach." Journal of Product Innovation Management **22**(3): 238-250.

Feldman, M. P. and D. B. Audretsch (1999). "Innovation in cities: Science-based diversity, specialization and localized competition." European Economic Review **43**(2): 409-429.

Feldman, M. P. and R. Florida (1994). "The Geographic Sources of Innovation: Technological Infrastructure and Product Innovation in the United States." Annals of the Association of American Geographers **84**(2): 210-229.

Freel, M. S. (2003). "Sectoral patterns of small firm innovation, networking and proximity." Research Policy **32**(5): 751-770.

Garcia, R. and R. Calantone (2002). "A critical look at technological innovation typology and innovativeness terminology: a literature review." Journal of Product Innovation Management **19**(2): 110-132.

Gatignon, H., M. L. Tushman, et al. (2002). "A Structural Approach to Assessing Innovation: Construct Development of Innovation Locus, Type, and Characteristics." MANAGEMENT SCIENCE **48**(9): 1103-1122.

Gemünden, H. G., T. Ritter, et al. (1996). "Network configuration and innovation success: An empirical analysis in German high-tech industries." International Journal of Research in Marketing **13**(5): 449-462.

Ghoshal, S. and P. Moran (1996). "Bad for practice: A critique of the transaction cost theory." Academy of Management Review **21**(1): 13-47.

Goerzen, A. and P. W. Beamish (2005). "The effect of alliance network diversity on multinational enterprise performance." Strategic Management Journal **26**(4): 333-354.

Goldenberg, J., D. R. Lehmann, et al. (2001). "The idea itself and the circumstances of its emergence as predictors of new product success." Management Science **47**(1): 69-84.

GomezMejia, L. R. and L. E. Palich (1997). "Cultural diversity and the performance of multinational firms." Journal of International Business Studies **28**(2): 309-335.

Grant, R. M. (1996). "Toward a knowledge-based theory of the firm." Strategic Management Journal **17**: 109-122.

Grant, R. M. and C. Baden-Fuller (2004). "A knowledge accessing theory of strategic alliances." Journal of Management Studies **41**(1): 61-84.

Green, S. G., M. B. Gavin, et al. (1995). "Assessing a multidimensional measure of radical technological innovation." Engineering Management, IEEE Transactions on **42**(3): 203-214.

Gulati, R. (1995). "DOES FAMILIARITY BREED TRUST - THE IMPLICATIONS OF REPEATED TIES FOR CONTRACTUAL CHOICE IN ALLIANCES." Academy of Management Journal **38**(1): 85-112.

Gulati, R. (1995). "Social structure and alliance formation patterns: A longitudinal analysis." Administrative Science Quarterly **40**(4): 619-652.

Gulati, R. (1998). "Alliances and networks." Strategic Management Journal **19**(4): 293-317.

Gulati, R., N. Nohria, et al. (2000). "Strategic networks." Strategic Management Journal **21**(3): 203-215.

Hagedoorn, J. (1993). "UNDERSTANDING THE RATIONALE OF STRATEGIC TECHNOLOGY PARTNERING - INTERORGANIZATIONAL MODES OF COOPERATION AND SECTORAL DIFFERENCES." Strategic Management Journal **14**(5): 371-385.

Hagedoorn, J. (2002). "Inter-firm R&D partnerships: an overview of major trends and patterns since 1960." Research Policy **31**(4): 477-492.

Hagedoorn, J. and M. Cloodt (2003). "Measuring innovative performance: is there an advantage in using multiple indicators?" Research Policy **32**(8): 1365-1379.

Hagedoorn, J. and J. Schakenraad (1994). "THE EFFECT OF STRATEGIC TECHNOLOGY ALLIANCES ON COMPANY PERFORMANCE." Strategic Management Journal **15**(4): 291-309.

Harabi, N. (2000). Innovation Through Vertical Relations Between Firms, Suppliers and Customers: Lessons from Germany, University of Applied Sciences Solothurn/Northwestern Switzerland.

Harabi, N. (2002). "The Impact of Vertical R&D Cooperation on Firm Innovation: An Empirical Investigation." Economics of Innovation and New Technology **11**(2): 93 - 108.

Henderson, R. M. and K. B. Clark (1990). "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established." Administrative Science Quarterly **v35**: 9-30.

Henttonen, K. (2006). Innovation in complex networks - The state-of-the-art and propositions for further research. The Innovation Pressure, International ProACT-conference 15-17th March. Tampere, Finland.

Hirshleifer, J. (1973). "Where Are We in the Theory of Information?" The American Economic Review **63**(2): 31-39.

Hobday, M. (1998). "Product complexity, innovation and industrial organisation." Research Policy **26**(6): 689-710.

Hollenstein, H. (1996). "A composite indicator of a firm's innovativeness. An empirical analysis based on survey data for Swiss manufacturing." Research Policy **25**(4): 633-645.

Inkmann, J. (2000). Horizontal and Vertical R&D Cooperation. CoFE Discussion Paper 00-02, Center of Finance and Econometrics, University of Konstanz.

Ireland, R. D., M. A. Hitt, et al. (2002). "Alliance management as a source of competitive advantage." Journal of Management **28**(3): 413-446.

Johannessen, J.-A., B. Olsen, et al. (2001). "Innovation as newness: what is new, how new, and new to whom?" European Journal of Innovation Management **Volume 4**(issue 1): pp. 20 - 31

Jorde, T. M. and D. J. Teece (1990). "INNOVATION AND COOPERATION - IMPLICATIONS FOR COMPETITION AND ANTITRUST." Journal of Economic Perspectives **4**(3): 75-96.

Kaufmann, A. and F. Todtling (2001). "Science-industry interaction in the process of innovation: the importance of boundary-crossing between systems." Research Policy **30**(5): 791-804.

Klaassen, G., A. Miketa, et al. (2003). Public R&D and Innovation: The Case of Wind Energy in Denmark, Germany and the United Kingdom. L. Schrattenholzer, International Institute for Applied Systems Analysis.

Kleinknecht, A., K. van Montfort, et al. (2002). "The Non-Trivial Choice between Innovation Indicators." Economics of Innovation and New Technology **11**(2): 109 - 121.

Kleinschmidt, E. J. and R. G. Cooper (1991). "The Impact of Product Innovativeness on Performance." Journal of Product Innovation Management **8**(4): 240-251.

Knudsen, M. P. (2007). "The relative importance of interfirm relationships and knowledge transfer for new product development success." Journal of Product Innovation Management **24**(2): 117-138.

Kogut, B. and U. Zander (1992). "KNOWLEDGE OF THE FIRM, COMBINATIVE CAPABILITIES, AND THE REPLICATION OF TECHNOLOGY." Organization Science **3**(3): 383-397.

Koschatzky, K. (1999). "Innovation networks of industry and business-related services--relations between innovation intensity of firms and regional inter-firm cooperation." European Planning Studies **7**(6): 737.

Kotha, S. (1995). "Mass Customization - Implementing the Emerging Paradigm for Competitive Advantage." Strategic Management Journal **16**: 21-42.

Koza, M. P. and A. Y. Lewin (1998). "The co-evolution of strategic alliances." Organization Science **9**(3): 255-264.

Laursen, K. and A. Salter (2006). "Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms." Strategic Management Journal **27**(2): 131-150.

Li, T. and R. J. Calantone (1998). "The impact of market knowledge competence on new product advantage: Conceptualization and empirical examination." Journal of Marketing **62**(4): 13-29.

Littler, D., F. Leverick, et al. (1995). "Factors Affecting the Process of Collaborative Product Development: A Study of UK Manufacturers of Information and Communications Technology Products." Journal of Product Innovation Management **12**(1): 16-32.

Love, J. H. and S. Roper (2001). "Location and network effects on innovation success: evidence for UK, German and Irish manufacturing plants." Research Policy **30**(4): 643-661.

March, J. G. (1991). "Exploration and Eploitation in organizational learning." Organization Science **Vol. 2**(No. 1): pp. 71-87.

McDonald, D. G. and J. Dimmick (2003). "The conceptualization and measurement of diversity." Communication Research **30**(1): 60-79.

Miotti, L. and F. Sachwald (2003). "Co-operative R&D: why and with whom? An integrated framework of analysis." Research Policy **32**(8): 1481-1499.

Mohnen, P. and C. Hoareau (2003). "What type of enterprise forges close links with universities and government labs? Evidence from CIS 2." Managerial and Decision Economics **24**(2-3): 133-145.

Mohr, J., S. Sengupta, et al. (2005). Marketing of high-technology products and innovation, Pearson Prentice Hall.

Mowery, D. C., J. E. Oxley, et al. (1998). "Technological overlap and interfirm cooperation: implications for the resource-based view of the firm." Research Policy **27**(5): 507-523.

Nooteboom, B. (1999). "Innovation, learning and industrial organisation." Cambridge Journal of Economics **23**(2): 127-150.

Nooteboom, B. (2000). "Learning by Interaction: Absorptive Capacity, Cognitive Distance and Governance." Journal of Management and Governance **4**(1): 69-92.

Nooteboom, B. (2003). Inter-Firm Collaboration, Learning and Networks An Integrated Approach Routledge, UK

OECD (2005). Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, third edition. Paris, OECD publishing.

Ottum, B. D. and W. L. Moore (1997). "The role of market information in new product success/failure." Journal of Product Innovation Management **14**(4): 258-273.

Palich, L. E. and L. R. Gomez-Mejia (1999). "A theory of global strategy and firm efficiencies: Considering the effects of cultural diversity." Journal of Management **25**(4): 587-606.

Parkhe, A. (1991). "INTERFIRM DIVERSITY, ORGANIZATIONAL LEARNING, AND LONGEVITY IN GLOBAL STRATEGIC ALLIANCES." Journal of International Business Studies **22**(4): 579-601.

Patil, G. P. and C. Taillie (1982). "Diversity as a Concept and its Measurement." Journal of the American Statistical Association **77**(379): 548-561.

Phelps, C. (2005). Technological Exploration: A Longitudinal Study of the Role of Recombinatory Search and Social Capital in Alliance Networks. PhD dissertation, University of Washington.

Pittaway, L., M. Robertson, et al. (2004). "Networking and innovation: a systematic review of the evidence." International Journal of Management Reviews **5-6**(3-4): 137-168.

Powell, W. W., K. W. Koput, et al. (1996). "Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology." Administrative Science Quarterly **41**(1): 116-145.

Ragatz, G. L., R. B. Handfield, et al. (1997). "Success factors for integrating suppliers into new product development." Journal of Product Innovation Management **14**(3): 190-202.

Ritter, T. and H. G. Gemunden (2003). "Network competence: Its impact on innovation success and its antecedents." Journal of Business Research **56**(9): 745-755.

Robertson, T. S. and H. Gatignon (1998). "Technology development mode: a transaction cost conceptualization." Strategic Management Journal **19**(6): 515-531.

Rodan, S. and C. Galunic (2004). "More than network structure: How knowledge heterogeneity influences managerial performance and innovativeness." Strategic Management Journal **25**(6): 541-562.

Romijn, H. and M. Albaladejo (2002). "Determinants of innovation capability in small electronics and software firms in southeast England." Research Policy **31**(7): 1053-1067.

Romijn, H. and M. Albu (2002). "Innovation, networking and proximity: Lessons from small high technology firms in the UK." Regional Studies **36**(1): 81-86.

Rothaermel, F. T. (2001). "Complementary assets, strategic alliances, and the incumbent's advantage: an empirical study of industry and firm effects in the biopharmaceutical industry." Research Policy **30**(8): 1235-1251.

Rothaermel, F. T. and D. L. Deeds (2004). "Exploration and exploitation alliances in biotechnology: A system of new product development." Strategic Management Journal **25**(3): 201-221.

Rothaermel, F. T. and D. L. Deeds (2006). "Alliance type, alliance experience and alliance management capability in high-technology ventures." Journal of Business Venturing **21**(4): 429-460.

Rothwell, R. (1994). "Towards the Fifth-generation Innovation Process " International Marketing Review **Volume 11**(Number 1): pp. 7-31(25).

Rowley, T. J. (1997). "Moving beyond dyadic ties: A network theory of stakeholder influences." Academy of Management Review **22**(4): 887-910.

Ruef, M. (2002). "Strong ties, weak ties and islands: structural and cultural predictors of organizational innovation." Industrial and Corporate Change **11**(3): 427-449.

Schumpeter, J. A. (1934). The theory of economic development; an inquiry into profits, capital, credit, interest, and the business cycle. Cambridge, Mass., Harvard University Press.

Schumpeter, J. A. (1947). "The creative response in economic history." Journal of Economic History **vol. 7** (No. 2): pp. 149–59.

Shan, W. J., G. Walker, et al. (1994). "INTERFIRM COOPERATION AND STARTUP INNOVATION IN THE BIOTECHNOLOGY INDUSTRY." Strategic Management Journal **15**(5): 387-394.

Smith, K. (2004). Measuring innovation. The Oxford handbook of innovation. J. Fagerberg, Oxford university press.

Spender, J. C. (1996). "Making knowledge the basis of a dynamic theory of the firm." Strategic Management Journal **17**: 45-62.

Stalk, G. (1988). "Time - the Next Source of Competitive Advantage." Harvard Business Review **66**(4): 41-51.

Stuart, T. E. (2000). "Interorganizational alliances and the performance of firms: A study of growth and innovation rates in a high-technology industry." Strategic Management Journal **21**(8): 791-811.

Tidd, J., J. Bessant, et al. (2005). Managing innovation - integrating technological, market and organizational change, John Wiley & sons, ltd.

Utterback, J. M. and W. J. Abernathy (1975). "A dynamic model of process and product innovation." Omega **3**(6): 639-656.

Veall, M. R. and K. F. Zimmermann (1996). PSEUDO-R2 MEASURES FOR SOME COMMON LIMITED DEPENDENT VARIABLE MODELS. **10:** 241-259.

Veryzer, R. W. (1998). "Discontinuous Innovation and the New Product Development Process." Journal of Product Innovation Management **15**(4): 304-321.

von Hippel, E. (1978). "SUCCESSFUL INDUSTRIAL PRODUCTS FROM CUSTOMER IDEAS." Journal of Marketing **42**(1): 39-49.

von Hippel, E. (1986). "Lead Users: A Source of Novel Product Concepts." Management Science **32**(7): 791-805.

von Hippel, E. (1987). "Cooperation between rivals: Informal know-how trading." Research Policy **16**(6): 291-302.

Wernerfelt, B. (1984). "A RESOURCE-BASED VIEW OF THE FIRM." Strategic Management Journal **5**(2): 171-180.

Williamson, O. E. (1981). "THE ECONOMICS OF ORGANIZATION - THE TRANSACTION COST APPROACH." American Journal of Sociology **87**(3): 548-577.

Williamson, O. E. (1985). Transaction cost economics. The economic institutions of capitalism : firms, markets, relational contracting. New York, Free Press.

Wooldridge, J. M. (2003). Introductory econometrics : a modern approach. Australia ;; Cincinnati, Ohio, South-Western College Pub.

Yao, E. and S. McEvily (2007). The Effects of Firm, Relational, and Network Knowledge Diversity on Innovation Performance. Working paper, University of Pittsburgh.

Zahra, S. A., R. D. Ireland, et al. (2000). "International expansion by new venture firms: International diversity, mode of market entry, technological learning, and performance." Academy of Management Journal **43**(5): 925-950.

Appendix A: Literature overview

Literature on cooperation and innovation in general

Author(s)	Year	Research type & data	Relevant findings
Baum, Calabrese, Silverman	2000	Empirical analysis Life history of 142 startup and 471 incumbent biotechnology firms in Canada	The strong impact on innovation-related performance is consistent with the widely held belief that alliance networks form a 'locus of innovation' in high-technology fields). It is also consistent with the alliance literature's emphasis on alliances as mechanisms to access or transfer technological knowledge and to facilitate innovative efforts
Faems, Van Looy, Debackere	2005	Empirical analysis Life history of 142 startup and 471 incumbent biotechnology firms in Canada	Based on these results, it can be concluded that the more firms engage in a variety of different inter-organizational collaborations, the more likely they are to create new or improved products that are commercially successful.
Freel	2002	Empirical analysis Survey of 597 SME manufacturing firms in the UK (2001)	It seems external collaboration is, unequivocally, neither a necessary nor less a sufficient condition for successful innovation.
Harabi	2002	Empirical analysis German MIP survey data (1993-1994)	In sum, both formal and informal cooperative arrangements between innovation producers, innovation users and suppliers are important. Innovation does require informal or formal coordination between agents operating at different stages of the innovative chain.
Henttonen	2006	Qualitative analysis 25 interviews with 132 participants at 3 multinational companies	PROPOSITION 11. Network-relations have and U-shaped relation to innovation output. On the one hand, number of network contacts can be seen to impact positively on innovative performance. However, too many network ties are hard to handled and hence, there might be an inversely U-shaped relationship between network relations and innovative performance.
Love, Roper	1999	Empirical analysis PDS survey of manufacturing plants. 1700 UK, 1500 Germany, 500 Ireland (1991-1994)	Where there is any significant effect, the relationship between R&D, technology transfer and networking is one of substitution rather than complementarily in the innovation process. In particular, our analysis provides no support for the contention that firms or plants in the UK, Ireland or Germany with more strongly developed external links (network or technology transfer) develop greater innovation intensity. Moreover inter-firm links also have no effect on the commercial success of plants' innovation activity, but intra-group links are important in terms of achieving commercial success.
Miotti, Sachwald	2002	Empirical analysis French CIS data (1994-1996)	Results support the why–who framework, which is founded on a resource-based perspective. Firms engage in R&D co-operation in order to complement their internal resources and accordingly team up with partners who control the relevant complementary resources—which are not necessarily frontier technologies.
Phelps	2005	Empirical analysis US patent data (1980-2002), SDC alliance data and aggregated financial data	Networking can have a positive impact on innovation in all organizational contexts (i.e. within established large organizations, small businesses and new entrepreneurial start-ups).
Rothwell	1994	Literature review	Essentially the main benefits of 5G derive from the efficient and real time handling of information across the whole system of innovation, including internal functions, suppliers, customers and collaborators, i.e. 5G is a process of parallel information processing, one in which electronic information processing and the more traditional informal face-to-face human contact operate in a complementary manner Industrial innovation can be depicted as a process of know-how accumulation, or learning process, involving elements of internal and external learning.
Shan, Walker, Kogut	1994	Empirical analysis BIOSCAN data of 114 biotechnology start-ups (1989)	In summary, this short study has found that innovation output of small firms and their cooperative agreements with large firms are not reciprocally related: innovation is explained by agreements, but not the reverse.
Stuart	2000	Empirical analysis 150 semiconductor companies in the U.S., Japan, Europe and southeast Asia	This study has offered additional evidence to confirm the prevalent assumption that strategic alliances can improve performance. In short, technology alliances with large and innovative partners improved baseline innovation and growth rates, but collaborations with small and technologically unsophisticated partners had an immaterial effect on performance.
Todtling, Kaufmann	1998	Empirical analysis REGIS survey data for Wales (UK), Wallonia (Belgium), Baden-Württemberg (Germany), Styria (Austria), the Basque country (Spain), Aveiro (Portugal), and Tampere (Finland) from 1996	Not surprisingly, we found that the innovative firms (the „innovation avant-garde") are better integrated into networks than the non-innovative firms. There were few differences between product and process innovators supporting the view of the interactive innovation model.

Literature on the role of customers

Author(s)	Year	Research type & data	Relevant findings
Atallah	2000	Literature review	Horizontal spillovers can increase R&D and welfare dependent on the setting, where vertical spillovers always increase R&D and welfare. Horizontal cooperation does not necessary increase R&D, other spillovers have to be taken into account.
Belderbos, Carree, Lokshin	2006	Empirical analysis Dutch CIS data (1996-1998)	Customer cooperation helps to increase market acceptance and diffusion of product innovations and enhances the impact of competitor and university cooperation.
Belderbos, Carree, Lokshin	2004	Empirical analysis Dutch CIS data (1996-1998)	cooperation with customers positively affects growth in sales per employee of products and services new to the market
Cassiman, Veugelers	2001	Empirical analysis Belgian CIS data (1990-1992)	Better appropriability of results of the innovation process, however, increases the probability of cooperating with customers or suppliers and is unrelated to cooperative agreements with research institutes. Cooperation with suppliers or customers reduces the effectiveness of strategic protection measures. This suggests that the commercially sensitive information that firms might disseminate indirectly through cooperative agreements with suppliers and customers could be detrimental to the efforts of the firm to appropriate the returns from its innovation process.
Ebersberger, Laursen, Saarinen, Salter	2005	Empirical analysis Finnish innovation database (1985-1998)	We found that new technological opportunities and collaboration with lead users appear to increase the radicalness of complex innovations.
Faems, Van Looy, Debackere	2005	Empirical analysis Belgian CIS data (1994-1996)	Collaborations with customers and suppliers—labeled as 'exploitative'—are associated positively with higher levels of turnover stemming from improved products
Gemünden, Ritter, Heydebreck	1996	Empirical analysis database obtained from fives studies of 321 biotechnology companies	Referring to our empirical findings, it is the synergy between supplier and customer interaction which makes product improvements more successful. Customer-orientation is critical for product innovation success, but it is not the isolated co-operation with customers which ensures product innovation success.
Harabi	2000	Empirical analysis German MIP survey data (1993-1994)	In sum, both formal and informal cooperative arrangements between innovation producers, innovation users and suppliers are important. Innovation does require informal or formal coordination between agents operating at different stages of the innovative chain.
Inkmann	2000	Empirical analysis German MIP survey data (1993-1994)	Distinguishing R&D competition and horizontal and vertical R&D cooperation between firms it turns out that vertical R&D cooperation usually maximizes the profits of the participating firms. Hence, the theoretical framework can explain vertical R&D agreements which clearly outnumber horizontal R&D agreements in practice.
Jorde, Teece	1990	Literature review	It is well understood that horizontal linkages can help overcome scale barriers in research; they can also assist in defining technical standards. In short, much innovation today is likely to require lateral and horizontal linkages as well as vertical ones. As we discuss below, and particularly for small firms, innovation may require accessing complementary assets which lie outside the organization. It is well understood that horizontal linkages can help overcome scale barriers in research; they can also assist in defining technical standards.
Knudsen	2007	Empirical analysis Know for Innovation survey data Covering Denmark, France, Germany, Greece, Holland, Italy, and the United Kingdom.	On the one hand customer relationships are used more often than other types of relationships but on the other hand that in both the original idea and the completion of the innovation stages, customer involvement had a negative impact on innovative performance. The term customer is most often used as if customers constitute a coherent whole with similar needs, wants, and preferences, but customers represent a very diverse set of relationships that should be managed as such. If the customers are lead users, Bonner and Walker (2004) argued that these users will resist new technology and products and will insist on incremental improvements to existing products, which are unlikely to create large shares of turnover—the dependent measure n this study.
Miotti, Sachwald	2002	Empirical analysis French CIS data (1994-1996)	Our framework nevertheless suggests that technology seeking is not the main objective of all R&D co-operations. In vertical R&D co-operation with suppliers or clients, the objective is to pool complementary resources and access more market information, presumably to better target innovation efforts. This confirms the perception that vertical R&D co-operation has become an important aspect of the incremental, day-to-day innovative process. Vertical co-operation only impacts the introduction of new products to the market.
Pittaway, Robertson, Munir, Denyer, Neely	2004	Literature review	The importance of networking with business customers is confirmed and is shown to offer many benefits. The nature of the value of networks with key customers needs to be treated with some caution. Such networking relationships appear to be ideal for promoting incremental innovation and customers can usefully help innovators identify market opportunities.
Romijn, Albu	2002	Qualitative/empirical analysis Interviews with 17 software and IT developers and 16 electronics firms in England	Customers did not show up as an important source of innovative performance could be that neither proximity nor high frequency in these contacts were associated with innovation excellence in the sample firms. It should not be concluded that customers had been unimportant as a source of innovation and learning in the sample firms as such.
Romijn, Albaladejo	2002	Empirical analysis survey of 33 small software and electronics companies in England held in 1998	Firms with local or even national customer networks appear to be performing comparatively less well. These findings concur with other recent research that points to the importance of a local–global interface, in which specific local network linkages contribute to success of small technology-based UK companies in global markets

Literature on the role of suppliers

Author(s)	Year	Research type & data	Relevant findings
Atallah	2000	Literature review	Horizontal spillovers can increase R&D and welfare dependent on the setting, where vertical spillovers always increase R&D and welfare. Horizontal cooperation does not necessary increase R&D, other spillovers have to be taken into account.
Belderbos, Carree, Lokshin	2004	Empirical analysis Dutch CIS data (1996-1998)	Supplier cooperation has a significant impact on labour productivity growth. The results confirm a major heterogeneity in the rationales and goals of R&D cooperation, with supplier cooperation focused on incremental innovations improving the productivity performance of firms.
Cassiman, Veugelers	2001	Empirical analysis Belgian CIS data (1990-1992)	Better appropriability of results of the innovation process increases the probability of cooperating with customers or suppliers and is unrelated to cooperative agreements with research institutes. Cooperation with suppliers or customers reduces the effectiveness of strategic protection measures. This suggests that the commercially sensitive information that firms might disseminate indirectly through cooperative agreements with suppliers and customers could be detrimental to the efforts of the firm to appropriate the returns from its innovation process.
Ebersberger, Laursen, Saarinen, Salter	2005	Empirical analysis Finnish innovation database (1985-1998)	Collaboration with suppliers was found to have neither an effect on the degree of complexity nor on the degree of novelty of the innovation
Faems, Van Looy, Debackere	2005	Empirical analysis Belgian CIS data (1994-1996)	Collaborations with customers and suppliers—labeled as 'exploitative'—are associated positively with higher levels of turnover stemming from improved products
Gemünden, Ritter, Heydebreck	1996	Empirical analysis database obtained from fives studies of 321 biotechnology companies	Referring to our empirical findings, it is the synergy between supplier and customer interaction which makes product improvements more successful.
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Inkmann	2000	Empirical analysis German MIP survey data (1993-1994)	Distinguishing R&D competition and horizontal and vertical R&D cooperation between firms it turns out that vertical R&D cooperation usually maximizes the profits of the participating firms. Hence, the theoretical framework can explain vertical R&D agreements which clearly outnumber horizontal R&D agreements in practice.
Jorde, Teece	1990	Literature review	It is well understood that horizontal linkages can help overcome scale barriers in research; they can also assist in defining technical standards. In short, much innovation today is likely to require lateral and horizontal linkages as well as vertical ones. As we discuss below, and particularly for small firms, innovation may require accessing complementary assets which lie outside the organization. It is well understood that horizontal linkages can help overcome scale barriers in research; they can also assist in defining technical standards.
Knudsen	2007	Empirical analysis Know for Innovation survey data Covering Denmark, France, Germany, Greece, Holland, Italy, and the United Kingdom.	Besides customers, the article found that suppliers and universities and PRIs are important external sources of knowledge for innovative performance.
Miotti, Sachwald	2002	Empirical analysis French CIS data (1994-1996)	Our framework nevertheless suggests that technology seeking is not the main objective of all R&D co-operations. In vertical R&D co-operation with suppliers or clients, the objective is to pool complementary resources and access more market information, presumably to better target innovation efforts. This confirms the perception that vertical R&D co-operation has become an important aspect of the incremental, day-to-day innovative process. Vertical co-operation only impacts the introduction of new products to the market.
Pittaway, Robertson, Munir, Denyer, Neely	2004	Literature review	the supply chain literature on networking behaviour and innovation shows that supply relationships are one of the most important networking arrangements affecting innovation performance and productivity
Ragatz, Handfield, Scannell	1997	Empirical analysis Survey to 210 members of the Michigan State University Global Procurement and Supply Chain Electronic Benchmarking Network (GEBN).	The responses to the Global Procurement and Supply Chain Benchmarking questionnaire regarding Supplier Integration Into New Product Development clearly indicate that supplier involvement in new product development is a strategically critical issue. Supplier integration has led to significant performance improvements and competitive advantages for the firms in this study, though not all integration efforts are successful.
Romijn, Albu	2002	Qualitative/empirical analysis Interviews with 17 software and IT developers and 16 electronics firms in England	Interaction with parties with complementary capabilities such as suppliers and service providers is also associated with high innovative performance.
Romijn, Albaladejo	2002	Empirical analysis survey of 33 small software and electronics companies in England held in 1998	The analysis did not provide much support for the contention that overall intensity of external networking would be conducive to innovativeness, nor that proximity to network partners in a general sense would contribute to this. Even so, a few specific types of local interactions clearly did appear to matter, notably those with R&D institutions and suppliers.

Literature on the role of competitors

Author(s)	Year	Research type & data	Relevant findings
Atallah	2000	Literature review	Horizontal spillovers can increase R&D and welfare dependent on the setting, where vertical spillovers always increase R&D and welfare. Horizontal cooperation does not necessary increase R&D, other spillovers have to be taken into account.
Baumol	1992	Literature review	Horizontal technology collusion has both positive as negative effects on innovation. Information sharing can increase development and dissemination speed and decrease innovation cost and risk. However with less competition there is less incentive to innovate and could lead to output restriction within cartels.
Belderbos, Carree, Lokshin	2004	Empirical analysis Dutch CIS data (1996-1998)	Competitor cooperation has a significant impact on labour productivity growth. The results confirm a major heterogeneity in the rationales and goals of R&D cooperation, with competitor cooperation focused on incremental innovations improving the productivity performance of firms. Competitor cooperation is also instrumental in creating and bringing to market radical innovations
Harabi	2002	Empirical analysis German MIP survey data (1993-1994)	The main benefits to be expected of such policies are: (i) overcoming the R&D financial constraints in individual firms (i.e. expensive research projects can be realized as a result of cost-sharing); (ii) exploitation of economies of scale and scope in R&D; (iii) reduction of wasteful duplication in R&D; (iv) internalization of technological spillovers and other forms of externality; (v) better use of synergies because each firm can contribute distinct capabilities to a common research project; and, finally, (vi) reduction of investment risks due to demand uncertainties. In short, horizontal R&D cooperation has been seen as a panacea for solving important aspects of market failure and other deficiencies in technology markets. Policies aimed at enhancing horizontal R&D cooperation between firms through government subsidies are, however, problematic in practice; they create costs for the economy at large. The major problem with these policies is that "... they can undermine incentives to conduct R&D (and other) operations efficiently, and may lead to cozy pricing arrangements for the products embodying that R&D. What is more, while monopolists may have the resources and opportunities to innovate, they lack the incentives to do so whenever the innovation threatens to displace any of their existing activities.
Inkmann	2000	Empirical analysis German MIP survey data (1993-1994)	Distinguishing R&D competition and horizontal and vertical R&D cooperation between firms it turns out that vertical R&D cooperation usually maximizes the profits of the participating firms. Hence, the theoretical framework can explain vertical R&D agreements which clearly outnumber horizontal R&D agreements in practice.
Jorde, Teece	1990	Literature review	It is well understood that horizontal linkages can help overcome scale barriers in research; they can also assist in defining technical standards. In short, much innovation today is likely to require lateral and horizontal linkages as well as vertical ones. As we discuss below, and particularly for small firms, innovation may require accessing complementary assets which lie outside the organization. It is well understood that horizontal linkages can help overcome scale barriers in research; they can also assist in defining technical standards.
Miotti, Sachwald	2002	Empirical analysis French CIS data (1994-1996)	Co-operation with rivals, which is quite rare, seems to be mostly used to share R&D costs in high-tech sectors—and not to work at the technological frontier.

Literature on the role of science partners

Author(s)	Year	Research type & data	Relevant findings
Belderbos, Carree, Lokshin	2004	Empirical analysis Dutch CIS data (1996-1998)	Cooperation with universities & research institutes positively affects growth in sales per employee of products and services new to the market. University cooperation is instrumental in creating and bringing to market radical innovations
Cassiman, Veugelers	2001	Empirical analysis Belgian CIS data (1990-1992)	Better appropriability of results of the innovation process, however, increases the probability of cooperating with customers or suppliers and is unrelated to cooperative agreements with research institutes. Cooperative agreements with research institutes increase the usefulness of the publicly available pool of knowledge and the effectiveness of appropriation mechanisms for the firm's innovation process.
Ebersberger, Laursen, Saarinen, Salter	2005	Empirical analysis Finnish innovation database (1985-1998)	Scientific breakthroughs tend to enhance the radicalness of innovations, regardless of the level of complexity, while R&D intensity tends to increase the level of complexity, regardless of the degree of novelty of the innovation. University collaboration tends to reduce the probability of producing simple and incremental innovations.
Faems, Van Looy, Debackere	2005	Empirical analysis Belgian CIS data (1994-1996)	Collaborations with universities and research organizations—labeled as 'explorative'—are associated with turnover levels related to new products.
Kaufmann, Todtling	2000	Empirical analysis REGIS survey data for Wales (UK), Wallonia (Belgium), Baden-Württemberg (Germany), Styria (Austria), the Basque country (Spain), Aveiro (Portugal), and Tampere (Finland) from 1996	As a consequence, firms cooperating with science increase their ability to realize more radical innovations and to introduce products which are new to the market. The results demonstrate that partners from science are more important than the firms' customers for the introduction of products which are new to the market.
Miotti, Sachwald	2002	Empirical analysis French CIS data (1994-1996)	Co-operation with public institutions involves firms that draw heavily on close to science external R&D sources. Moreover, such R&D co-operation has a positive

			impact on patenting
Pittaway, Robertson, Munir, Denyer, Neely	2004	Literature review	The evidence on science partners shows that they contribute to innovation networks, usually through informal-personal networks and that their contribution is important in enabling firms to develop thinking that steps outside their particular business system. The evidence demonstrates that science partners tend to be most important where the innovation is relatively radical in orientation
Romijn, Albu	2002	Qualitative/empirical analysis Interviews with 17 software and IT developers and 16 electronics firms in England	An important finding relates to the importance of scientific institutions in the region as sources of highly innovative science-based start-ups, and as contributors at ongoing innovative processes in these companies long after their establishment. The contribution of these institutions obviously does not lie in fostering technology-driven entrepreneurs in large numbers, but rather in their ability to nurture a limited number of highly successful firms that are capable of securing competitive advantage based on patentable innovations in leading overseas markets. These are the sort of companies that the UK government is especially interested in bolstering.
Romijn, Albaladejo	2002	Empirical analysis survey of 33 small software and electronics companies in England held in 1998	The analysis did not provide much support for the contention that overall intensity of external networking would be conducive to innovativeness, nor that proximity to network partners in a general sense would contribute to this. Even so, a few specific types of local interactions clearly did appear to matter, notably those with R&D institutions and suppliers.

Literature on the difference of public and private science partners

Author(s)	Year	Research type & data	Relevant findings
Cassiman, Veugelers	2005	Empirical analysis Belgian CIS data (1990-1992)	Firms impeded by costs to innovate are more likely to cooperate with universities, attracted by the often government subsidized cost-sharing in public–private partnerships. However risk sharing was not found to be associated with cooperation with universities.
Cooke, Wills	2004	Empirical analysis Survey of 153 SME's in Denmark, Ireland and Wales (1996-1998)	But its embeddedness correlate of synergy in the sense of strong public-private relationships is even more salient, as a means for assisting firms to move beyond largely local embeddedness.
Etzkowitz, Leydesdorff	2000	Literature review	In one form or another, most countries and regions are presently trying to attain some form of Triple Helix III. The common objective is to realize an innovative environment consisting of university pin-off firms, tri-lateral initiatives for knowledge based economic development, and strategic alliances among firms large and small, operating in different areas, and with different levels of technology, government laboratories, and academic research groups. These arrangements are often encouraged, but not controlled, by government, whether through new ''rules of the game,'' direct or indirect financial assistance, or through the Bayh–Dole Act in the USA or new actors such as the abovementioned foundations to promote innovation in Sweden.
Gemünden, Ritter, Heydebreck	1996	Empirical analysis database obtained from fives studies of 321 biotechnology companies	In addition, the university plays an important role in developing new products, at least within high-tech industries.
Knudsen	2007	Empirical analysis Know for Innovation survey data Covering Denmark, France, Germany, Greece, Holland, Italy, and the United Kingdom.	Besides customers, the article found that suppliers and universities and PRIs are important external sources of knowledge for innovative performance.
Mohnen, Hoareau	2003	Empirical analysis CIS data (1994-1996) from France, , Ireland, Germany and Spain	R&D-intensive firms and radical innovators tend to source knowledge from universities and government labs but not to cooperate with them directly. Outright collaborations in innovation with universities and government labs in characteristic of large firms, firms that patent or those that receive government support for innovation.
Pittaway, Robertson, Munir, Denyer, Neely	2004	Literature review	In general, the role of third parties, such as professional associations, trade associations and publicly funded bodies specifically aimed at promoting innovation (such as technology transfer centers) have a positive impact on the development of inter-organizational networks and innovation

Literature on diversity of partners in general

Author(s)	Year	Research type & data	Relevant findings
Baum, Calabrese, Silverman	2000	Empirical analysis Life history of 142 startup and 471 incumbent biotechnology firms in Canada	Variety in composition of alliance networks of start-ups in biotechnology strongly (positively) influences innovation performance.
Cummings	2004	Qualitative/empirical analysis Field study of 182 work groups in large telecommunication firms	External knowledge sharing was more strongly associated with performance when work groups were more structurally diverse. In contrast, demographic diversity did not yield the same benefits, suggesting that not all sources of diversity in work groups enhance the value of knowledge.
Feldmann, Audretsch	1998	Empirical analysis US based SBIDB database of around 8000 innovations introduced in 1982	By focusing on innovative activity for particular industries at specific locations, we find compelling evidence that specialization of economic activity does not promote innovative output. Rather, the results indicate that diversity across complementary economic activities sharing a common science base is more conducive to innovation than is specialization
Goerzen, Beamish	2005	Empirical analysis Survey of around 13000 subsidiaries of 580 Japanese MNE's (1999)	In effect, the firm that implements a less focused strategy that combines these two polar extremes (focused, homogeneous network strategy vs. diverse network strategy) appears to suffer, on average, relatively weaker economic results. This is an interesting result given that an important stream of academic research has implied that diverse alliance networks place the firm in a superior competitive position since it would have better access to resources on a timely basis. This research suggests to managers that as equity-based alliance networks become increasingly diverse, the benefits of network alliance diversity appear to diminish as the costs increase.
Henttonen	2006	Qualitative analysis 25 interviews with 132 participants at 3 multinational companies	PROPOSITION 10. The (internal and external) greater the network heterogeneity (demographic and scientific) of the R&D and innovation project teams the greater the R&D teams subsequent innovation output.
Kaufmann, Todtling	2000	Empirical analysis REGIS survey data for Wales (UK), Wallonia (Belgium), Baden-Württemberg (Germany), Styria (Austria), the Basque country (Spain), Aveiro (Portugal), and Tampere (Finland) from 1996	It is of crucial importance, however, that the systemic diversity is maintained in order to improve the innovative performance of the involved firms.
Knudsen	2007	Empirical analysis Know for Innovation survey data Covering Denmark, France, Germany, Greece, Holland, Italy, and the United Kingdom.	The industry association of the most important relationship is studied, and the results show that firms tend to partner with firms from their own industry. The danger in this approach is that firms from their own industry tend to contribute similar knowledge, which ultimately may endanger the creation of new knowledge and therefore more radical product developments.
Laursen, Salter	2006	Empirical analysis UK CIS data (1998-2000)	Indeed, the results strongly suggest that searching widely and deeply across a variety of search channels can provide ideas and resources that help firms gain and exploit innovative opportunities. Innovation search is, however, not costless. It can be time consuming, expensive, and laborious. It appears that there are moments or tipping points after which openness—in terms of breadth and depth—can negatively affect innovative performance.
Mcevily, Zaheer	1999	Empirical analysis sample of 227 job shop manufacturers located in the Midwest United States	We theorize and demonstrate that one source of important firm heterogeneity is the idiosyncratic and unique manner in which firms are embedded in networks. Since firms are each embedded in highly differentiated ways, they occupy unique network positions that link them to different sets of players and thereby present them with distinct opportunities and constraints.
Nooteboom	2003	Literature review	Diversity is associated with the number of agents (people, firms) with different knowledge and/or skills, who are involved in a process of learning or innovation by interaction. However, next to the number of agents involved, a second dimension of diversity is the degree to which their knowledge or skills are different.
Nooteboom	2000	Literature review	This brings us back to a crucial possible liability of networks: tight and durable networking between firms may block radical innovation.
Phelps	2005	Empirical analysis US patent data (1980-2002), SDC alliance data and aggregated financial data	I found that network-level technological diversity had a positive, linear effect on technological exploration. Network density enhanced technological exploration and the interaction of diversity and density exhibited a positive effect on technological exploration.
Rodan, Galunic	2004	Empirical analysis Survey of 106 managers at a Scandinavian telecommunications company	Our findings suggest that, while network structure matters, access to heterogeneous knowledge is of equal importance for overall managerial performance and of greater importance for innovation performance.
Ruef	2002	Empirical analysis Survey of 766 entrepreneurs (1999)	A third model explores the impact of network diversity on perceptions of creative action. Entrepreneurs who are embedded in heterogeneous networks, comprising a mixture of strong ties, weak ties and advisors with no prior relationship, are significantly more likely to attempt innovation than entrepreneurs in homogeneous networks. in particular, social networks with maximum information entropy (completely heterogeneous ties) encourage innovation at almost three times the rate of networks with no entropy (completely homogenous ties)
Yao, McEvily	2007	Empirical analysis Aggregated financial data and aggregated alliance data on 228 pharmaceutical firms (1990-1999)	We found that the diversity of knowledge at each level positively affects a firm's innovativeness. This supports the view that innovation results from the recombination of distinct elements of knowledge and that variation stimulates creativity. Our results differ somewhat from prior studies that found a linear relationship between the scope of a firm's search across technological domains, as indicated by patterns of prior art citations on a firm's patents, and its innovativeness (Rosenkopf and Nerkar, 2001; Ahuja and Katila, 2001). We found a curvilinear relationship between the diversity of a firm's knowledge, and the degree to which its alliance partners possess expertise distinct from its own, and innovation performance.

Literature on stakeholder diversity

Author(s)	Year	Research type & data	Relevant findings
Belderbos, Carree, Lokshin	2006	Empirical analysis Dutch CIS data (1996-1998)	Testing whether different types of R&D cooperation are complements in improving productivity, showed it could be either beneficial or detrimental for firm performance.
Gemünden, Ritter, Heydebreck	1996	Empirical analysis database obtained from fives studies of 321 biotechnology companies	Our findings show that process innovation success needs multi-dimensional co-operation with multiple actors as well: be it through an intensive interaction with universities and consultants or through a balanced network pattern. It is of particular interest to notice that only a high intensity of interweavement secures process innovation success.
Knudsen	2007	Empirical analysis Know for Innovation survey data Covering Denmark, France, Germany, Greece, Holland, Italy, and the United Kingdom.	The divergence in knowledge exchange and the perspective of the external partners counteracts instead of adding complementary and potentially synergy creating resources.
Pittaway, Robertson, Munir, Denyer, Neely	2004	Literature review	The evidence shows that the innovation process, particularly complex and radical innovation processes, benefits from engagement with a diverse range of partners which allows for the integration of different knowledge bases, behaviours and habits of thought. Formal and informal communication between people with different information, skills and values increases the chance of unforeseen novel combinations of knowledge, which can lead to radical discoveries

Literature on geographic diversity

Author(s)	Year	Research type & data	Relevant findings
Ebersberger, Laursen, Saarinen, Salter	2005	Empirical analysis Finnish innovation database (1985-1998)	With respect to our three “geographical” collaboration variables we found that “no collaboration” involved in the innovation process tends to decrease the level of radicalness of the innovation, while for national collaboration, such collaboration tends to lower the odds of radical innovation among complex innovations, and finally, the degree of international innovation enhances the probability of bringing about a radical innovation which is at the same time complex. Accordingly, the overall picture is (with some qualifications) that the (geographical) width of collaboration tends to enhance the radicalness and complexity of innovations.
Freel	2002	Empirical analysis Survey of 597 SME manufacturing firms in the UK (2001)	Novel innovators (i.e. those introducing products or processes new to the industry) are marked by the greater geographical reach of their innovation networks, whilst incremental product innovators appear to be more locally embedded.
Gomez-mejia, Palich	1997	Empirical analysis Longitudinal data on international involvement and performance of Fortune 500 firms (1985-1994)	The results of this study indicate that, after controlling for a variety of organizational and industry characteristics, the direction of a firm's international expansion in terms of cultural relatedness or unrelatedness has no effect on subsequent accounting and market measures of performance
Miotti, Sachwald	2002	Empirical analysis French CIS data (1994-1996)	Firms tend to draw on their home country-specific resources in order to build up their competitive advantages. As a result, firms may view R&D co-operation with foreign partners as a way to access indigenous resources from the latter’s home country.
Palich, Gomez-mejia	1999	Literature review	Tempering popular perspectives that extol the benefits of diversity, the present theory posits that cultural diversity among international divisions of a global firm may actually impede efforts to merge activities and expertise between those units.
Romijn, Albaladejo	2002	Empirical analysis survey of 33 small software and electronics companies in England held in 1998	Firms with local or even national customer networks appear to be performing comparatively less well. These findings concur with other recent research that points to the importance of a local–global interface, in which specific local network linkages contribute to success of small technology-based UK companies in global markets
Zahra, Ireland, Hitt	2000	Empirical analysis Survey of 321 high-tech companies in the US (1993)	Increasingly, new ventures are entering international markets early in their life cycles. The results show a strong relationship between international diversity and mode of market entry and the breadth, depth and speed of a new venture firm’s technological learning, especially when the firm undertakes formal knowledge integration.

Appendix B: R&D expenditure regression over years

```
. regress rtot_2004 rtot_2002

      Source |       SS       df       MS              Number of obs =    3090
-------------+------------------------------           F(  1,  3088) =63580.81
       Model |  1.8020e+12     1  1.8020e+12           Prob > F      =  0.0000
    Residual |  8.7519e+10  3088  28341644.4           R-squared     =  0.9537
-------------+------------------------------           Adj R-squared =  0.9537
       Total |  1.8895e+12  3089   611687816           Root MSE      =  5323.7

------------------------------------------------------------------------------
   rtot_2004 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   rtot_2002 |    1.007701   .0039964   252.15   0.000     .9998648    1.015537
       _cons |    581.3039   95.95536     6.06   0.000     393.1611    769.4467
------------------------------------------------------------------------------


. test rtot_2002 = 1

       F(  1,  3088) =    3.71
            Prob > F =    0.0541


. regress rtot_2004 rtot_2000

      Source |       SS       df       MS              Number of obs =    3090
-------------+------------------------------           F(  1,  3088) =26733.36
       Model |  1.6938e+12     1  1.6938e+12           Prob > F      =  0.0000
    Residual |  1.9566e+11  3088  63360751.7           R-squared     =  0.8965
-------------+------------------------------           Adj R-squared =  0.8964
       Total |  1.8895e+12  3089   611687816           Root MSE      =  7959.9

------------------------------------------------------------------------------
   rtot_2004 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   rtot_2000 |    .8693971   .0053173   163.50   0.000     .8589713     .8798229
       _cons |    747.7082    143.428     5.21   0.000     466.4842    1028.932
------------------------------------------------------------------------------


. test rtot_2000 = 1

       F(  1,  3088) =  603.29
            Prob > F =    0.0000


. regress rtot_2004 rtot_1998

      Source |       SS       df       MS              Number of obs =    3090
-------------+------------------------------           F(  1,  3088) =17859.23
       Model |  1.6110e+12     1  1.6110e+12           Prob > F      =  0.0000
    Residual |  2.7855e+11  3088  90203047.7           R-squared     =  0.8526
-------------+------------------------------           Adj R-squared =  0.8525
       Total |  1.8895e+12  3089   611687816           Root MSE      =  9497.5

------------------------------------------------------------------------------
   rtot_2004 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   rtot_1998 |    1.313315   .0098274   133.64   0.000     1.294046    1.332584
       _cons |    989.0661   171.0517     5.78   0.000     653.6794    1324.453
------------------------------------------------------------------------------


. test rtot_1998 = 1

       F(  1,  3088) = 1016.45
            Prob > F =    0.0000
```

Appendix C: CIS survey

The Fourth Community Innovation Survey
(CIS IV)

THE HARMONISED SURVEY QUESTIONNAIRE

The Fourth Community Innovation Survey **(Variable names: October 20 2004)**

This survey collects information about product and process innovation as well as organisational and marketing innovation during the three-year period 2002 to 2004 inclusive. Most questions cover new or significantly improved goods or services or the implementation of new or significantly improved processes, logistics or distribution methods. Organisational and marketing innovations are only covered in section 10. In order to be able to compare enterprises with and without innovation activities, we request all enterprises to respond to **all** questions, unless otherwise instructed.

Person we should contact if there are any queries regarding the form:

Name: _____
Job title: _____
Organisation: _____
Phone: _____
Fax: _____
E-mail: _____

General information about the enterprise

Name of enterprise _____ *ID*

Address[1] _____ *NUTS*

Postal code _____ Main activity[2] _____ *NACE*

1.1 Is your enterprise part of an enterprise group? *GP*

(A group consists of two or more legally defined enterprises under common ownership. Each enterprise in the group may serve different markets, as with national or regional subsidiaries, or serve different product markets. The head office is also part of an enterprise group.)

Yes ☐ In which country is the head office of your group located? [3] _____ *HO*

No ☐

If your enterprise is part of an enterprise group, please answer all further questions only for your enterprise in [your country]. Do not include results for subsidiaries or parent enterprises outside of [your country]

1.2 In which geographic markets did your enterprise sell goods or services during the three years 2002 to 2004?

	Yes	No	
Local / regional within [your country]	☐	☐	*MARLOC*
National	☐	☐	*MARNAT*
Other European Union (EU) countries, EFTA, or EU candidate countries*	☐	☐	*MAREUR*
All other countries	☐	☐	*MAROTH*

*: Include the following countries: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Ireland, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Slovakia, Switzerland, Turkey, Spain, Sweden and the United Kingdom.

[1] NUTS 2 code

[2] NACE 4 digit code

[3] Country code according to ISO standard

2

2. Product (good or service) innovation

A product innovation is the market introduction of a **new** good or service or a **significantly** improved good or service with respect to its capabilities, such as improved software, user friendliness, components or sub-systems. The innovation (new or improved) must be new to your enterprise, but it does not need to be new to your sector or market. It does not matter if the innovation was originally developed by your enterprise or by other enterprises.

2.1 During the three years 2002 to 2004, did your enterprise introduce:

	Yes	No	
New or significantly improved goods. (Exclude the simple resale of new goods purchased from other enterprises and changes of a solely aesthetic nature.)	☐	☐	*INPDGD*
New or significantly improved services.	☐	☐	*INPDSV*

If no to both options, go to question 3.1, otherwise:

2.2 Who developed these product innovations? *INPDTW*

Select the most appropriate option only

Mainly your enterprise or enterprise group	☐
Your enterprise together with other enterprises or institutions	☐
Mainly other enterprises or institutions	☐

2.3 Were any of your goods and service innovations during the three years 2002 to 2004:

		Yes	No	
New to your market?	Your enterprise introduced a new or significantly improved good or service onto your market before your competitors (it may have already been available in other markets)	☐	☐	*NEWMKT*
Only new to your firm?	Your enterprise introduced a new or significantly improved good or service that was already available from your competitors in your market	☐	☐	*NEWFRM*

Using the definitions above, please give the percentage of your total turnover[4] in 2004 from:

Goods and service innovations introduced during 2002 to 2004 that were **new to your market**	☐☐☐ %	*TURNMAR*
Goods and service innovations introduced during 2002 to 2004 that were **only new to your firm**	☐☐☐ %	*TURNIN*
Goods and services that were **unchanged or only marginally modified** during 2002 to 2004 (include the resale of new goods or services purchased from other enterprises)	☐☐☐ %	*TURNUNG*
Total turnover in 2004	1 0 0 %	

[4] For Credit institutions: Interests receivable and similar income, for insurance services: Gross premiums written

3. Process innovation

A process innovation is the implementation of a **new** or **significantly** improved production process, distribution method, or support activity for your goods or services. The innovation (new or improved) must be new to your enterprise, but it does not need to be new to your sector or market. It does not matter if the innovation was originally developed by your enterprise or by other enterprises. Exclude purely organisational innovations.

3.1 During the three years 2002 to 2004, did your enterprise introduce:

	Yes	No	
New or significantly improved methods of manufacturing or producing goods or services	☐	☐	*INPSPD*
New or significantly improved logistics, delivery or distribution methods for your inputs, goods or services	☐	☐	*INPSLG*
New or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing	☐	☐	*INPSSU*

If no to all options, go to section 4, otherwise:

3.2 Who developed these process innovations? *INPCSW*

Select the most appropriate option only

- Mainly your enterprise or enterprise group ☐
- Your enterprise together with other enterprises or institutions ☐
- Mainly other enterprises or institutions ☐

4. Ongoing or abandoned innovation activities

Innovation activities include the acquisition of machinery, equipment, software, and licenses; engineering and development work, training, marketing and R&D[5] when they are *specifically* undertaken to develop and/or implement a product or process innovation.

4.1 Did your enterprise have any innovation activities to develop product or process innovations that were abandoned during 2002 to 2004 or still ongoing by the end of 2004?

Yes ☐

No ☐ *INONAB*

If your enterprise had no product or process innovations or innovation activity during 2002 to 2004 (no to all options in questions 2.1, 3.1, and 4.1), go to question 8.2.

Otherwise, go to question 5.1

[5] Include basic R&D as an innovation activity even if not specifically related to a product and/or process innovation

5. Innovation activities and expenditures

5.1 During the three years 2002 to 2004, did your enterprise engage in the following innovation activities:

		Yes	No	
Intramural (in-house) R&D	Creative work undertaken within your enterprise to increase the stock of knowledge and its use to devise new and improved products and processes (including software development)	☐	☐	*RRDIN*
	If yes, did your firm perform R&D during 2002 to 2004: Continuously? ☐ Occasionally? ☐			*RDENG*
Extramural R&D	Same activities as above, but performed by other companies (including other enterprises within your group) or by public or private research organisations and purchased by your enterprise	☐	☐	*RRDEX*
Acquisition of machinery, equipment and software	Acquisition of advanced machinery, equipment and computer hardware or software to produce new or significantly improved products and processes	☐	☐	*RMAC*
Acquisition of other external knowledge	Purchase or licensing of patents and non-patented inventions, know-how, and other types of knowledge from other enterprises or organisations	☐	☐	*ROEK*
Training	Internal or external training for your personnel specifically for the development and/or introduction of new or significantly improved products and processes	☐	☐	*RTR*
Market introduction of innovations	Activities for the market introduction of your new or significantly improved goods and services, including market research and launch advertising	☐	☐	*RMAR*
Other preparations	Procedures and technical preparations to implement new or significantly improved products and processes that are not covered elsewhere.	☐	☐	*RPRE*

5.2 Please estimate the amount of expenditure for each of the following four innovation activities in 2004 only. (Include personnel and related costs)[6]

	Tick 'nil' if your enterprise had no expenditures in 2004 **Nil**	
Intramural (in-house) R&D (Include capital expenditures on buildings and equipment specifically for R&D)	☐	*RRDINX*
Acquisition of R&D (extramural R&D)	☐	*RRDEXX*
Acquisition of machinery, equipment and software (Exclude expenditures on equipment for R&D)	☐	*RMACX*
Acquisition of other external knowledge	☐	*ROEKX*
Total of these four innovation expenditure categories	☐	*RTOT*

[6] Give expenditure data in national currency units to eight digits.

6

** Page 5 of the innovation survey is a blank page*

5.3 During the three years 2002 to 2004, did your enterprise receive any public financial support for innovation activities from the following levels of government? Include financial support via tax credits or deductions, grants, subsidised loans, and loan guarantees. Exclude research and other innovation activities conducted entirely for the public sector under contract.

	Yes	No	
Local or regional authorities	☐	☐	*FUNLOC*
Central government (including central government agencies or ministries)	☐	☐	*FUNGMT*
The European Union (EU)	☐	☐	*FUNEU*
If yes, did your firm participate in the EU's 5th (1998-2002) or 6th (2003-2006) Framework Programme for Research and Technical Development	☐	☐	*FUNRTD*

6. Sources of information and co-operation for innovation activities

6.1 During the three years 2002 to 2004, how important to your enterprise's innovation activities were each of the following information sources? Please identify information sources that provided information for new innovation projects or contributed to the completion of existing innovation projects.

		Degree of importance *Tick 'not used' if no information was obtained from a source.*				
	Information source	**High**	**Medium**	**Low**	**Not used**	
Internal	Within your enterprise or enterprise group	☐	☐	☐	☐	*SENTG*
Market sources	Suppliers of equipment, materials, components, or software	☐	☐	☐	☐	*SSUP*
	Clients or customers	☐	☐	☐	☐	*SCLI*
	Competitors or other enterprises in your sector	☐	☐	☐	☐	*SCOM*
	Consultants, commercial labs, or private R&D institutes	☐	☐	☐	☐	*SINS*
Institutional sources	Universities or other higher education institutions	☐	☐	☐	☐	*SUNI*
	Government or public research institutes	☐	☐	☐	☐	*SGMT*
Other sources	Conferences, trade fairs, exhibitions	☐	☐	☐	☐	*SCON*
	Scientific journals and trade/technical publications	☐	☐	☐	☐	*SJOU*
	Professional and industry associations	☐	☐	☐	☐	*SPRO*

7

6.2 During the three years 2002 to 2004, did your enterprise co-operate on any of your innovation activities with other enterprises or institutions? Innovation co-operation is active participation with other enterprises or non-commercial institutions on innovation activities. Both partners do not need to commercially benefit. Exclude pure contracting out of work with no active co-operation.

Yes ☐
No ☐ **(Please go to question 7.1)** *CO*

6.3 Please indicate the type of co-operation partner and location *(Tick all that apply)*

Type of co-operation partner	[Your country]	Other Europe*	United States	All other countries
A. Other enterprises within your enterprise group	*Co11*	*Co12*	*Co13*	*Co14*
B. Suppliers of equipment, materials, components, or software	*Co21*	*Co22*	*Co23*	*Co24*
C. Clients or customers	*Co31*	*Co32*	*Co33*	*Co34*
D. Competitors or other enterprises in your sector	*Co41*	*Co42*	*Co43*	*Co44*
E. Consultants, commercial labs, or private R&D institutes	*Co51*	*Co52*	*Co53*	*Co54*
F. Universities or other higher education institutions	*Co61*	*Co62*	*Co63*	*Co64*
G. Government or public research institutes	*Co71*	*Co72*	*Co73*	*Co74*

*: Include the following European Union (EU) countries, EFTA, or EU candidate countries: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Ireland, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Slovakia, Switzerland, Turkey, Spain, Sweden and the United Kingdom.

6.4 Which type of co-operation partner did you find the most valuable for your enterprise's innovation activities? (Give corresponding letter) _____ *PMOS*

7. Effects of innovation during 2002-2004

7.1 How important were each of the following effects of your product (good or service) and process innovations introduced during the three years 2002 to 2004?

		Degree of observed effect				
		High	Medium	Low	Not relevant	
Product oriented effects	Increased range of goods or services	☐	☐	☐	☐	*ERANGE*
	Entered new markets or increased market share	☐	☐	☐	☐	*EMAR*
	Improved quality of goods or services	☐	☐	☐	☐	*EQUA*
	Improved flexibility of production or service provision	☐	☐	☐	☐	*EFLEX*
Process oriented effects	Increased capacity of production or service provision	☐	☐	☐	☐	*ECAP*
	Reduced labour costs per unit output	☐	☐	☐	☐	*ELBR*
	Reduced materials and energy per unit output	☐	☐	☐	☐	*EMAT*
Other effects	Reduced environmental impacts or improved health and safety	☐	☐	☐	☐	*EENV*
	Met regulatory requirements	☐	☐	☐	☐	*ESTD*

8

8. Factors hampering innovation activities

8.1 During the three years 2002 to 2004, were any of your innovation activities or projects:

	Yes	No	
Abandoned in the concept stage	☐	☐	*HCON*
Abandoned after the activity or project was begun	☐	☐	*HBEG*
Seriously delayed	☐	☐	*HDLAY*

TO BE ANSWERED BY ALL ENTERPRISES:

8.2 During the three years 2002 to 2004, how important were the following factors for hampering your innovation activities or projects or influencing a decision not to innovate?

		Degree of importance				
		High	Medium	Low	Factor not experienced	
Cost factors	Lack of funds within your enterprise or group	☐	☐	☐	☐	*HFENT*
	Lack of finance from sources outside your enterprise	☐	☐	☐	☐	*HFOUT*
	Innovation costs too high	☐	☐	☐	☐	*HCOS*
Knowledge factors	Lack of qualified personnel	☐	☐	☐	☐	*HPER*
	Lack of information on technology	☐	☐	☐	☐	*HTEC*
	Lack of information on markets	☐	☐	☐	☐	*HINF*
	Difficulty in finding cooperation partners for innovation	☐	☐	☐	☐	*HPAR*
Market factors	Market dominated by established enterprises	☐	☐	☐	☐	*HDOM*
	Uncertain demand for innovative goods or services	☐	☐	☐	☐	*HDEM*
Reasons not to innovate	No need due to prior innovations	☐	☐	☐	☐	*HPRIOR*
	No need because of no demand for innovations	☐	☐	☐	☐	*HMAR*

9. Intellectual property rights

9.1 During the three years 2002 to 2004, did your enterprise:

	Yes	No	
Apply for a patent	☐	☐	*PROPAT*
Register an industrial design	☐	☐	*PRODSG*
Register a trademark	☐	☐	*PROTM*
Claim copyright	☐	☐	*PROCP*

10. Organisational and marketing innovations

An organisational innovation is the implementation of new or significant changes in firm structure or management methods that are intended to improve your firm's use of knowledge, the quality of your goods and services, or the efficiency of work flows. A marketing innovation is the implementation of new or significantly improved designs or sales methods to increase the appeal of your goods and services or to enter new markets.

10.1 During the three years 2002 to 2004, did your enterprise introduce:

		Yes	No	
Organisational innovations	New or significantly improved knowledge management systems to better use or exchange information, knowledge and skills within your enterprise	☐	☐	*ORGSYS*
	A major change to the organisation of work within your enterprise, such as changes in the management structure or integrating different departments or activities	☐	☐	*ORGSTR*
	New or significant changes in your relations with other firms or public institutions, such as through alliances, partnerships, outsourcing or sub-contracting	☐	☐	*ORGREL*
Marketing innovations	Significant changes to the design or packaging of a good or service (Exclude routine/ seasonal changes such as clothing fashions)	☐	☐	*MKTDES*
	New or significantly changed sales or distribution methods, such as internet sales, franchising, direct sales or distribution licenses.	☐	☐	*MKTMET*

10.2 If your enterprise introduced an organisational innovation during the three years 2002 to 2004, how important were each of the following effects?

	Degree of observed effect				
	High	Medium	Low	Not relevant	
Reduced time to respond to customer or supplier needs	☐	☐	☐	☐	*EFORED*
Improved quality of your goods or services	☐	☐	☐	☐	*EFORQU*
Reduced costs per unit output	☐	☐	☐	☐	*EFORCO*
Improved employee satisfaction and/or reduced rates of employee turnover	☐	☐	☐	☐	*EFORSA*

11. Basic economic information on your enterprise

11.1 What was your enterprise's total turnover for 2002 and 2004?[7] Turnover is defined as the market sales of goods and services (include all taxes except VAT[8]).

2002	2004
☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐
TURN02	*TURN04*

11.2 What was your enterprise's total number of employees in 2002 and 2004?[9]

2002	2004
☐☐☐☐☐☐☐☐	☐☐☐☐☐☐☐☐
EMP02	*EMP04*

[7] Give turnover in '000 of national currency units to nine digits.

[8] For Credit institutions: Interests receivable and similar income; for Insurance services: Gross premiums written

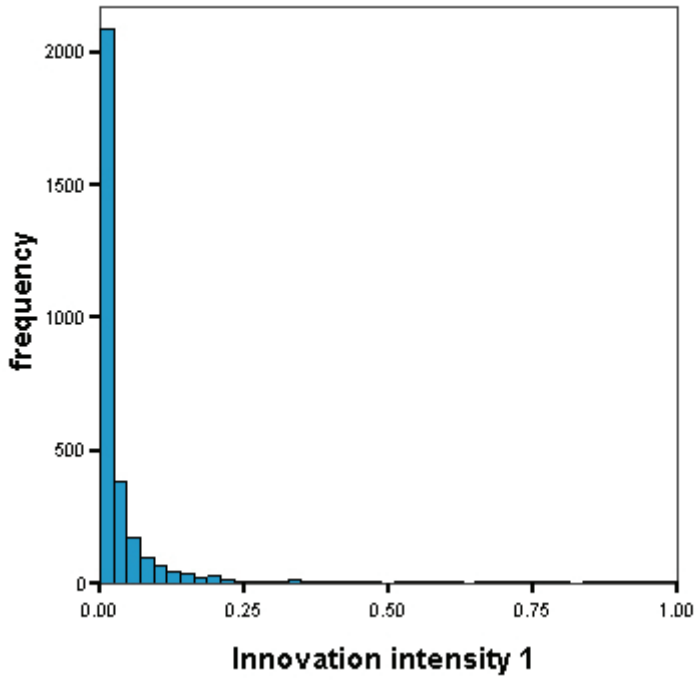
[9] Annual average. If not available, give the number of employees at the end of each year. Give figures to six digits.

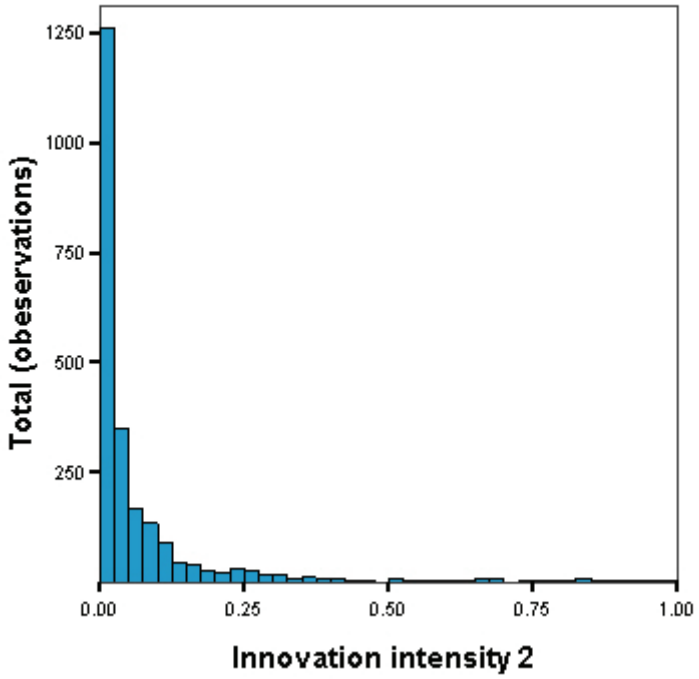
Appendix D: SBI '93 industry sector classification

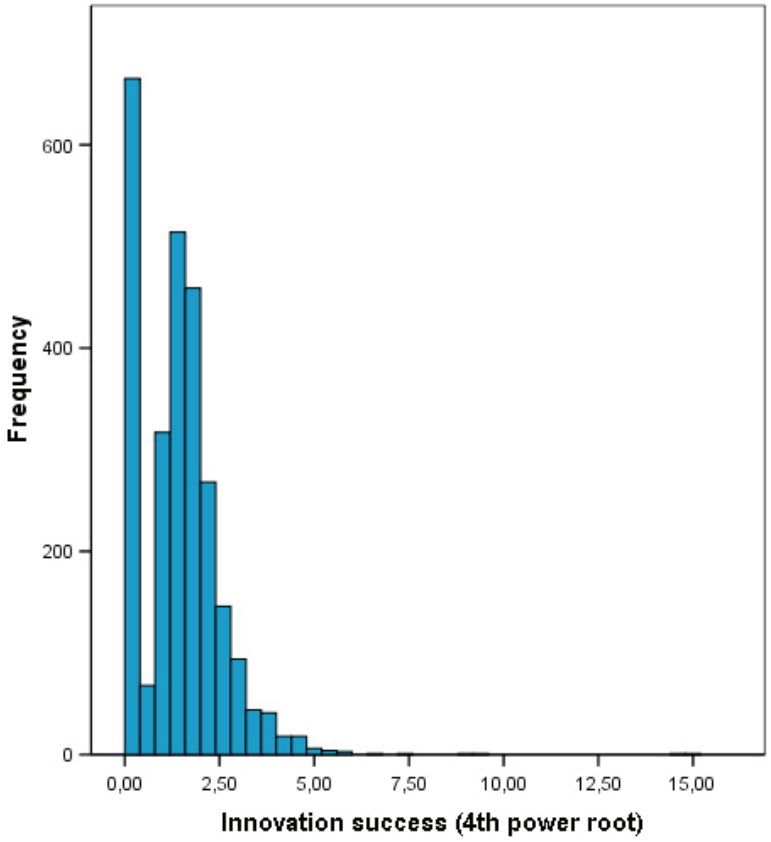
SBI code	Dutch description (SBI)	English description (SIC)
1	Landbouw, bosbouw en visserij	Agriculture, Hunting, Forestry and Fishing
10	Delfstoffenwinning	Mining and Quarrying
15	Voedings- en genotmiddelenindustrie	Manufacture of Food Products, Beverages and Tobacco
17	Textiel- en lederindustrie	Manufacture of Textiles, Leather and Wood (Products)
21	Papierindustrie	Manufacture of Pulp, Paperand Paper Products
22	Uitgeverijen en drukkerijen	Publishing, Printing and Reproduction of Recorded Media
23	Aardolie-industrie	Manufacture of Coke, Refined Petroleum Products and Nuclear Fuel
24	Chemische industrie	Manufacture of Chemicals and Chemical Products
25	Rubber- en kunststofindustrie	Manufacture of Rubber, Plastic and other Non-metallic Mineral ProductsProducts
27	Basismetaalindustrie	Manufacture of Basic Metals
28	Metaalproductenindustrie	Manufacture of Fabricated Metal Products, Except Machinery and Equipment
29	Machine-industrie	Manufacture of Machinery and Equipment Not Elsewhere Classified
30	Elektrotechnische industrie	Manufacture of Electrical and Optical Equipment
34	Transportmiddelenindustrie	Manufacture of Transport Equipment
36	Overige industrie	Manufacturing Not Elsewhere Classified
40	Energie, gas en water	Electricity, Gas and Water Supply
45	Bouwnijverheid	Construction
51	Groothandel	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles
52	Detailhandel en reparatie	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Personal and Household Goods
55	Horeca en autohandel	Hotels and Restaurants
60	Vervoer en communicatie	Transport, Storage and Communication
65	Financiële instellingen	Financial Intermediation and Real Estate
72	Computerservicebureaus e.d.	Computer and Related Activities
73	Speurwerkinstellingen	Research and Development
74	Overige zakelijke dienstverlening	Other Business Activities
80	Onderwijs en gezondheids- en welzijnszorg	Education, Health and Social Work
90	Milieudienstverlening	Sewage and Refuse Disposal, Sanitation and Similar Activities
92	Multimedia (film/video, radio/tv, uitleencentra)	Recreational, Cultural and Sporting Activities
93	Overige dienstverlening	Other Service Activities

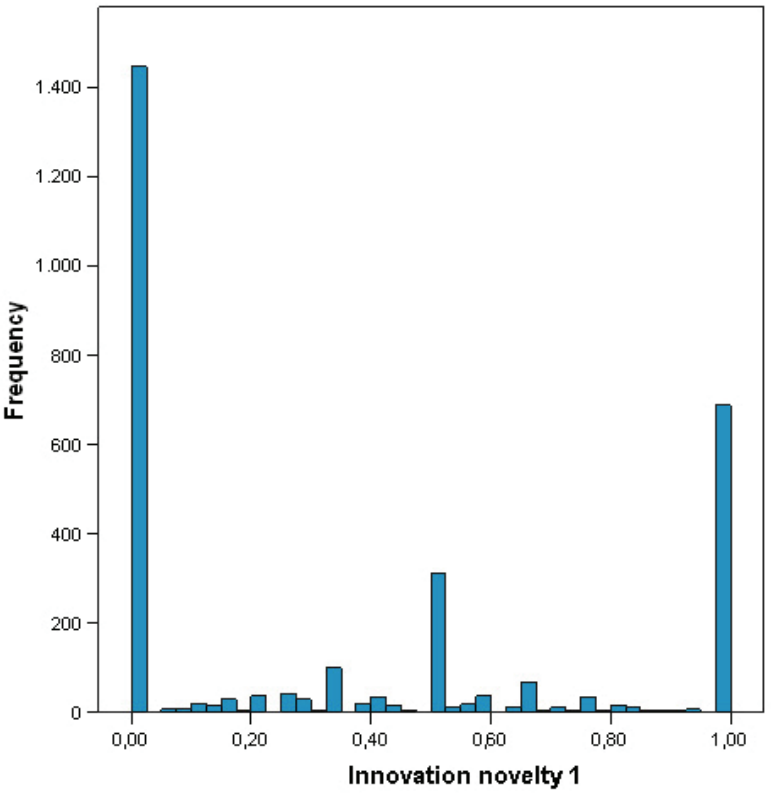
Appendix E: Descriptive plots of dependent variables

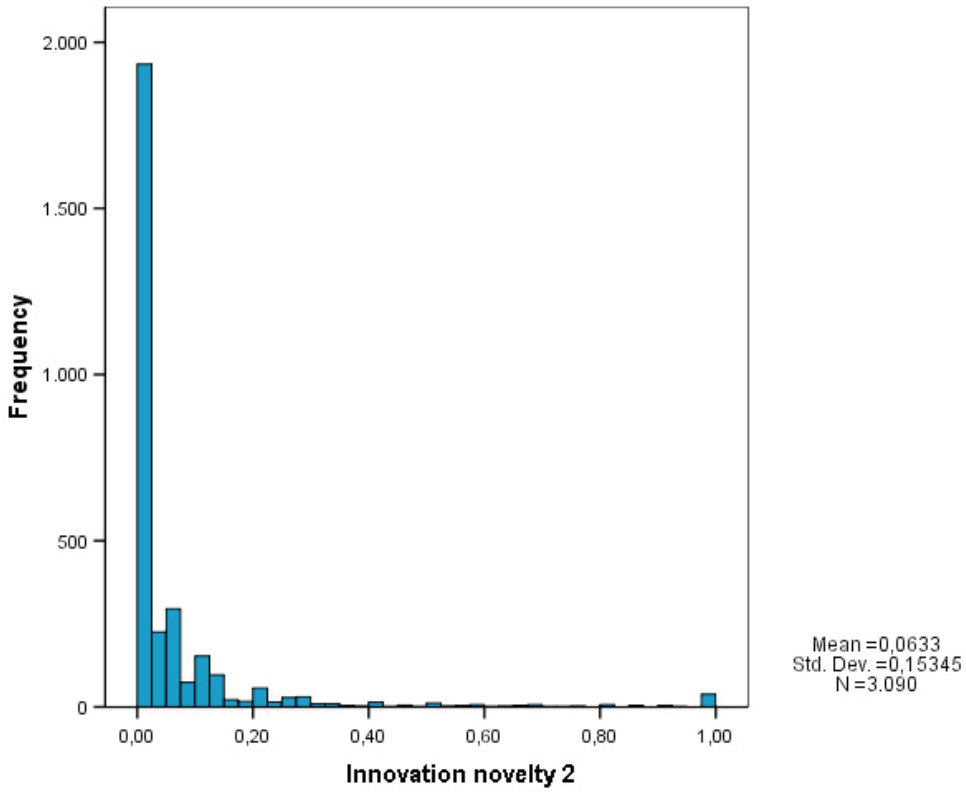
Descriptive plots of dependent variables






Frequency
600
400
200
0
0,00
2,50
5,00
7,50
10,00
12,50
15,00
Innovation success (4th power root)
Mean =1,4037
Std. Dev. =1,15707
N =2.671


Frequency
1.400
1.200
1.000
800
600
400
200
0
0,00
0,20
0,40
0,60
0,80
1,00
Innovation novelty 1
Mean =0,3663
Std. Dev. =0,40797
N =3.090


2.000
1.500
1.000
500
0
Frequency
0,00
0,20
0,40
0,60
0,80
1,00
Innovation novelty 2
Mean =0,0633
Std. Dev. =0,15345
N =3.090

Appendix F: Interval regression models

In this appendix the complete interval regression models, including industry dummies are provided. Also the stepwise interval regression for each model is provided. The appendix will be continued on the next page due to lay out purposes.

Innovation intensity 1 complete models

Independent variables	Model 1a Coeff.	Model 1a Robust S.E.	Model 1b Coeff.	Model 1b Robust S.E.	Model 1c Coeff.	Model 1c Robust S.E.
geodiversity	0.0631 ***	0.0122	0.0570 ***	0.0118	0.0086	0.0156
custcoop	-0.0153 *	0.0092	-0.0143	0.0091	-0.0237 *	0.0133
suppcoop	-0.0037	0.0076	-0.0028	0.0077	0.0274 **	0.0118
compcoop	-0.0028	0.0075	-0.0019	0.0074	-0.0044	0.0130
scprcoop	0.0069	0.0093	0.0064	0.0092	0.0030	0.0136
scpucoop	0.0091	0.0078	0.0068	0.0077	0.0045	0.0115
stakediversity	0.0122	0.0253	0.0078	0.0253	0.0130	0.0379
logemp2004	-0.0192 ***	0.0049	-0.0216 ***	0.0050	-0.0217 ***	0.0049
foreignmult	-0.0154 ***	0.0043	-0.0146 ***	0.0043	-0.0131 ***	0.0042
group	0.0001	0.0170	-0.0035	0.0167	-0.0019	0.0166
abscap			0.0298 ***	0.0044	0.0332 ***	0.0054
abs_geodiv					0.0730 ***	0.0214
abs_custco					0.0120	0.0181
abs_suppco					-0.0505 ***	0.0149
abs_compco					-0.0001	0.0160
abs_scprco					0.0043	0.0175
abs_scpuco					-0.0015	0.0151
abs_stakediv					0.0040	0.0504
sbi_1	0.0278	0.0180	0.0321 *	0.0178	0.0319 *	0.0174
sbi_10	0.1295 *	0.0683	0.1286 *	0.0690	0.1276 *	0.0682
sbi_15	0.0006	0.0093	0.0007	0.0094	-0.0001	0.0095
sbi_17	-0.0084	0.0107	-0.0082	0.0113	-0.0110	0.0118
sbi_21	0.0350	0.0225	0.0356	0.0236	0.0347	0.0239
sbi_22	0.0466 **	0.0198	0.0513 **	0.0201	0.0508 ***	0.0195
sbi_23	0.0380	0.0358	0.0349	0.0346	0.0380	0.0372
sbi_24	0.0394 ***	0.0140	0.0383 ***	0.0142	0.0335 **	0.0139
sbi_25	0.0123	0.0118	0.0110	0.0116	0.0101	0.0118
sbi_27	-0.0074	0.0111	-0.0077	0.0102	-0.0045	0.0106
sbi_28	0.0122	0.0100	0.0151	0.0101	0.0161	0.0101
sbi_29	0.0112	0.0085	0.0083	0.0086	0.0059	0.0087
sbi_30	0.0276 **	0.0112	0.0250 **	0.0112	0.0242 **	0.0111
sbi_34	-0.0072	0.0081	-0.0088	0.0083	-0.0094	0.0086
sbi_40	0.1082 *	0.0558	0.1131 **	0.0570	0.1170 **	0.0558
sbi_45	-0.0022	0.0112	0.0035	0.0114	0.0031	0.0115
sbi_51	-0.0124	0.0089	-0.0069	0.0091	-0.0076	0.0092
sbi_52	-0.0183	0.0206	-0.0095	0.0209	-0.0106	0.0211
sbi_55	-0.0229 **	0.0111	-0.0139	0.0113	-0.0141	0.0116
sbi_60	-0.0106	0.0089	-0.0034	0.0092	-0.0048	0.0092
sbi_65	-0.0072	0.0119	-0.0007	0.0120	0.0012	0.0121
sbi_72	0.0579 ***	0.0175	0.0568 ***	0.0171	0.0563 ***	0.0169
sbi_74	0.0076	0.0093	0.0122	0.0095	0.0121	0.0095
sbi_80	-0.0433	0.0385	-0.0221	0.0389	-0.0389	0.0356
sbi_90	0.0185	0.0192	0.0270	0.0204	0.0270	0.0205
sbi_93	0.0096	0.0177	0.0133	0.0200	0.0068	0.0203
_cons	0.0476 **	0.0202	0.0379 *	0.0199	0.0345 *	0.0202
pseudo R2	0.103		0.118		0.127	
Log likelihood	1294.6		1316.7		1328.3	
Chi-squared	158.76		180.99		191.72	
observations	1807		1807		1807	

** p < 0.10, ** p < 0.05, *** p < 0.01*

Innovation intensity 1 stepwise models

Independent variables	Model 1a Coeff.	Robust S.E.		
geodiversity	0.0632 ***	0.0115	pseudo R2	0.100
custcoop	-0.0109 *	0.0057	Log likelihood	1289.65
sbi_30	0.0334 ***	0.0091	Chi-squared	141
sbi_74	0.0139 **	0.0066	observations	1807
sbi_25	0.0183 *	0.0098		
scpucoop	0.0148 **	0.0061		
sbi_72	0.0639 ***	0.0163		
logemp2004	-0.0178 ***	0.0048		
foreignmult	-0.0160 ***	0.0043		
sbi_40	0.1167 **	0.0550		
sbi_1	0.0344 **	0.0169		
sbi_10	0.1360 **	0.0683		
sbi_28	0.0182 **	0.0075		
sbi_55	-0.0159 *	0.0085		
sbi_21	0.0411 *	0.0216		
sbi_22	0.0526 ***	0.0186		
sbi_29	0.0183 ***	0.0053		
sbi_24	0.0456 ***	0.0125		
_cons	0.0387 ***	0.0102		

* p < 0.10, ** p < 0.05, *** p < 0.01

Independent variables	Model 1b Coeff.	Robust S.E.		
geodiversity	0.0564 ***	0.0111	pseudo R2	0.116
custcoop	-0.0114 **	0.0057	Log likelihood	1313.77
sbi_25	0.0142	0.0095	Chi-squared	164.54
sbi_74	0.0159 **	0.0065	observations	1807
sbi_28	0.0184 **	0.0073		
scpucoop	0.0111 *	0.0061		
sbi_72	0.0600 ***	0.0156		
logemp2004	-0.0203 ***	0.0048		
foreignmult	-0.0150 ***	0.0043		
sbi_30	0.0279 ***	0.0090		
abscap	0.0305 ***	0.0043		
sbi_1	0.0359 **	0.0164		
sbi_10	0.1325 *	0.0689		
sbi_90	0.0316	0.0193		
sbi_40	0.1184 **	0.0563		
sbi_21	0.0391 *	0.0228		
sbi_22	0.0546 ***	0.0190		
sbi_29	0.0124 **	0.0052		
sbi_24	0.0417 ***	0.0126		
_cons	0.0283 ***	0.0101		

* p < 0.10, ** p < 0.05, *** p < 0.01

Independent variables	Model 1c Coeff.	Robust S.E.		
sbi_40	0.1205 **	0.0556	**pseudo R2**	0.124
custcoop	-0.0162 **	0.0080	**Log likelihood**	1323.43
suppcoop	0.0230 ***	0.0086	**Chi-squared**	169.65
sbi_30	0.0274 ***	0.0089	**observations**	1807
sbi_28	0.0195 ***	0.0073		
sbi_90	0.0302	0.0191		
stakediversity	0.0213	0.0139		
logemp2004	-0.0206 ***	0.0048		
foreignmult	-0.0130 ***	0.0042		
sbi_72	0.0594 ***	0.0153		
abscap	0.0348 ***	0.0052		
abs_geodiv	0.0853 ***	0.0136		
sbi_22	0.0546 ***	0.0183		
abs_suppco	-0.0440 ***	0.0096		
sbi_21	0.0384 *	0.0230		
sbi_29	0.0098 *	0.0051		
sbi_74	0.0153 **	0.0064		
sbi_24	0.0375 ***	0.0126		
sbi_1	0.0354 **	0.0157		
sbi_10	0.1322 *	0.0676		
_cons	0.0265 ***	0.0102		

* p < 0.10, ** p < 0.05, *** p < 0.01

Innovation intensity 2 complete models

Independent variables	Model 2a Coeff.	Model 2a Robust S.E.	Model 2b Coeff.	Model 2b Robust S.E.	Model 2c Coeff.	Model 2c Robust S.E.
geodiversity	0.1162 ***	0.0162	0.1071 ***	0.0157	0.0568 **	0.0226
custcoop	-0.0061	0.0113	-0.0056	0.0111	-0.0332 **	0.0148
suppcoop	-0.0336 ***	0.0101	-0.0316 ***	0.0099	-0.0128	0.0129
compcoop	0.0011	0.0117	0.0035	0.0116	-0.0063	0.0148
scprcoop	-0.0023	0.0122	-0.0006	0.0120	-0.0045	0.0170
scpucoop	0.0165	0.0109	0.0150	0.0107	0.0016	0.0154
stakediversity	0.0284	0.0334	0.0201	0.0329	0.0644	0.0430
logemp2004	-0.0575 ***	0.0094	-0.0612 ***	0.0094	-0.0615 ***	0.0094
foreignmult	-0.0007	0.0072	-0.0009	0.0071	0.0001	0.0072
group	-0.0602	0.0480	-0.0669	0.0480	-0.0653	0.0480
abscap			0.0550 ***	0.0073	0.0516 ***	0.0104
abs_geodiv					0.0614 **	0.0280
abs_custco					0.0332 *	0.0200
abs_suppco					-0.0241	0.0182
abs_compco					0.0116	0.0201
abs_scprco					0.0042	0.0221
abs_scpuco					0.0153	0.0208
abs_stakediv					-0.0514	0.0605
sbi_1	0.1022 **	0.0503	0.1088 **	0.0488	0.1073 **	0.0491
sbi_10	0.0944	0.0846	0.0892	0.0842	0.0885	0.0842
sbi_15	0.0199	0.0122	0.0202 *	0.0121	0.0195	0.0122
sbi_17	-0.0121	0.0122	-0.0119	0.0129	-0.0135	0.0133
sbi_21	-0.0125	0.0122	-0.0126	0.0130	-0.0149	0.0135
sbi_22	0.0268	0.0324	0.0237	0.0313	0.0273	0.0318
sbi_23	0.0917	0.0568	0.0748	0.0565	0.0763	0.0575
sbi_24	0.0684 ***	0.0154	0.0646 ***	0.0152	0.0614 ***	0.0152
sbi_25	0.0169 *	0.0095	0.0163 *	0.0092	0.0170 *	0.0092
sbi_27	0.0124	0.0150	0.0134	0.0135	0.0142	0.0138
sbi_28	-0.0026	0.0087	0.0019	0.0087	0.0030	0.0089
sbi_29	0.0397 ***	0.0115	0.0358 ***	0.0115	0.0338 ***	0.0117
sbi_30	0.0673 ***	0.0168	0.0632 ***	0.0168	0.0627 ***	0.0167
sbi_34	0.0101	0.0099	0.0079	0.0103	0.0077	0.0110
sbi_40	0.0799	0.0726	0.0870	0.0749	0.0890	0.0745
sbi_45	0.0156	0.0115	0.0242 **	0.0115	0.0239 **	0.0116
sbi_51	0.0245 *	0.0129	0.0284 **	0.0128	0.0264 **	0.0130
sbi_52	0.0069	0.0194	0.0067	0.0195	0.0116	0.0198
sbi_55	-0.0379 **	0.0168	-0.0255 *	0.0153	-0.0259	0.0159
sbi_60	-0.0065	0.0104	0.0017	0.0104	0.0010	0.0105
sbi_65	0.0257	0.0189	0.0295	0.0189	0.0299	0.0194
sbi_72	0.1430 ***	0.0293	0.1396 ***	0.0291	0.1386 ***	0.0292
sbi_74	0.0356 **	0.0143	0.0394 ***	0.0144	0.0390 ***	0.0143
sbi_80	-0.0746	0.0659	-0.0328	0.0645	-0.0591	0.0602
sbi_90	-0.0274	0.0185	-0.0083	0.0200	-0.0094	0.0202
sbi_93	0.0018	0.0196	0.0029	0.0223	0.0056	0.0229
_cons	0.1805 ***	0.0504	0.1553 ***	0.0506	0.1567 ***	0.0519
pseudo R2	0.164		0.188		0.192	
Log likelihood	719.58		743.82		746.48	
Chi-squared	191.8		230.58		238.52	
observations	1407		1407		1407	

** p < 0.10, ** p < 0.05, *** p < 0.01*

Innovation intensity 2 stepwise models

Independent variables	Model 2a Coeff.	Robust S.E.		
geodiversity	0.1149 ***	0.0163	pseudo R2	0.153
sbi_55	-0.0615 ***	0.0164	Log likelihood	708.615
suppcoop	-0.0290 ***	0.0070	Chi-squared	146.49
sbi_90	-0.0502 ***	0.0182	observations	1407
sbi_28	-0.0253 ***	0.0076		
scpucoop	0.0273 ***	0.0079		
sbi_21	-0.0344 ***	0.0111		
logemp2004	-0.0581 ***	0.0091		
sbi_30	0.0427 ***	0.0164		
sbi_72	0.1210 ***	0.0294		
sbi_1	0.0777	0.0502		
sbi_29	0.0167	0.0109		
sbi_17	-0.0344 ***	0.0115		
sbi_24	0.0443 ***	0.0147		
sbi_60	-0.0305 ***	0.0087		
_cons	0.1459 ***	0.0198		

* p < 0.10, ** p < 0.05, *** p < 0.01

Independent variables	Model 2b Coeff.	Robust S.E.		
geodiversity	0.1055 ***	0.0157	pseudo R2	0.180
sbi_28	-0.0252 ***	0.0071	Log likelihood	735.541
suppcoop	-0.0289 ***	0.0070	Chi-squared	171.41
sbi_60	-0.0250 ***	0.0085	observations	1407
sbi_55	-0.0515 ***	0.0144		
scpucoop	0.0242 ***	0.0078		
sbi_30	0.0356 **	0.0162		
logemp2004	-0.0613 ***	0.0090		
sbi_24	0.0372 ***	0.0145		
group	-0.0724	0.0473		
abscap	0.0559 ***	0.0073		
sbi_1	0.0818 *	0.0486		
sbi_34	-0.0193 **	0.0088		
sbi_72	0.1124 ***	0.0286		
sbi_17	-0.0394 ***	0.0119		
sbi_21	-0.0395 ***	0.0120		
_cons	0.1877 ***	0.0502		

* p < 0.10, ** p < 0.05, *** p < 0.01

Independent variables	Model 2c Coeff.	Robust S.E.		
geodiversity	0.0494 **	0.0196	**pseudo R2**	0.182
custcoop	-0.0385 ***	0.0131	**Log likelihood**	736.972
sbi_30	0.0383 **	0.0162	**Chi-squared**	171.96
sbi_55	-0.0532 ***	0.0150	**observations**	1407
sbi_72	0.1125 ***	0.0286		
sbi_17	-0.0381 ***	0.0121		
stakediversity	0.0471 ***	0.0147		
logemp2004	-0.0614 ***	0.0091		
sbi_21	-0.0390 ***	0.0119		
group	-0.0729	0.0475		
abscap	0.0541 ***	0.0095		
abs_geodiv	0.0729 ***	0.0250		
abs_custco	0.0303 **	0.0151		
abs_suppco	-0.0439 ***	0.0102		
sbi_24	0.0366 **	0.0145		
sbi_60	-0.0246 ***	0.0083		
sbi_1	0.0833 *	0.0486		
sbi_28	-0.0224 ***	0.0069		
_cons	0.1882 ***	0.0513		

* p < 0.10, ** p < 0.05, *** p < 0.01

Innovation success complete models

Independent variables	Model 3a Coeff.	Model 3a Robust S.E.	Model 3b Coeff.	Model 3b Robust S.E.	Model 3c Coeff.	Model 3c Robust S.E.
geodivdum	0.2117	0.2038	0.2002	0.2046	0.8271 *	0.4542
custcodum	0.4367 ***	0.1244	0.4390 ***	0.1247	0.7693 ***	0.2745
suppcodum	-0.2298 *	0.1176	-0.2271 *	0.1176	-0.4326 *	0.2247
compcodum	0.1916 *	0.1159	0.1928 *	0.1157	0.3267	0.2932
scprcodum	-0.0672	0.1246	-0.0670	0.1247	0.3325	0.2940
scpucodum	-0.0735	0.1474	-0.0777	0.1469	-0.3981	0.3345
stakedivdum	-0.1784	0.3567	-0.1872	0.3573	-0.4874	0.7165
logemp2004	0.1385 **	0.0650	0.1355 **	0.0651	0.1336 **	0.0643
foreignmult	-0.0178	0.0756	-0.0170	0.0755	-0.0354	0.0747
group	0.2277	0.2684	0.2206	0.2692	0.1813	0.2723
abscap			0.0551	0.0833	0.1875 *	0.1086
ad_geodiv					-0.9031 *	0.5015
ad_custco					-0.4189	0.2996
ad_suppco					0.3152	0.2618
ad_compco					-0.1602	0.3136
ad_scprco					-0.5346 *	0.3236
ad_scpuco					0.5283	0.3629
ad_stakediv					0.2359	0.8158
sbi_1	0.0329	0.3214	0.0415	0.3210	0.0699	0.3171
sbi_10	-0.1271	0.3678	-0.1258	0.3688	-0.1646	0.3714
sbi_15	0.3724 **	0.1891	0.3731 **	0.1889	0.3728 **	0.1885
sbi_17	-0.0009	0.2412	-0.0002	0.2404	0.0373	0.2478
sbi_21	0.1869	0.2639	0.1881	0.2629	0.2389	0.2624
sbi_22	-0.1462	0.2317	-0.1399	0.2316	-0.1591	0.2316
sbi_23	-1.0026	0.7191	-1.0078	0.7121	-1.0612	0.7109
sbi_24	-0.3226 *	0.1929	-0.3256 *	0.1924	-0.2645	0.1906
sbi_25	0.0450	0.1941	0.0432	0.1937	0.0317	0.1959
sbi_27	-0.0476	0.3211	-0.0450	0.3205	-0.0963	0.3240
sbi_28	-0.0990	0.2082	-0.0935	0.2075	-0.0889	0.2065
sbi_29	-0.0098	0.1728	-0.0150	0.1730	0.0313	0.1748
sbi_30	0.0899	0.1804	0.0853	0.1806	0.1083	0.1800
sbi_34	0.2668	0.2271	0.2630	0.2274	0.2674	0.2274
sbi_40	0.0268	0.4341	0.0364	0.4350	0.0121	0.4150
sbi_45	-0.0710	0.2281	-0.0626	0.2276	-0.0474	0.2257
sbi_51	0.4479 **	0.1882	0.4566 **	0.1868	0.4696 **	0.1878
sbi_52	-1.0739 ***	0.3447	-1.0619 ***	0.3445	-1.1146 ***	0.3470
sbi_55	-0.0059	0.4282	0.0077	0.4276	0.0154	0.4292
sbi_60	0.0540	0.2443	0.0656	0.2447	0.0658	0.2433
sbi_65	-0.1815	0.3143	-0.1729	0.3137	-0.1444	0.3216
sbi_72	-0.0581	0.1992	-0.0624	0.1993	-0.0690	0.1965
sbi_74	-0.0898	0.1790	-0.0821	0.1790	-0.0848	0.1788
sbi_80	-0.9377	1.0392	-0.8954	1.0448	-0.5271	1.0932
sbi_90	-0.2874	0.3988	-0.2728	0.3997	-0.4009	0.4105
sbi_93	-1.0210	0.6719	-1.0099	0.6748	-1.0775	0.6692
_cons	0.7748 **	0.3302	0.7528 **	0.3316	0.7178 **	0.3384
pseudo R2	0.044		0.044		0.052	
Log likelihood	-2495.7		-2495.4		-2485.5	
Chi-squared	82.03		83.96		91.12	
observations	1581		1581		1581	

** p < 0.10, ** p < 0.05, *** p < 0.01*

Innovation success stepwise models

Independent variables	Model 3a Coeff.	Robust S.E.		
sbi_93	-1.0176	0.6493	pseudo R2	0.037
custcodum	0.4444 ***	0.0889	Log likelihood	-2502.32
suppcodum	-0.2345 ***	0.0848	Chi-squared	67.49
sbi_15	0.4010 ***	0.1313	observations	1581
sbi_51	0.4878 ***	0.1315		
sbi_24	-0.2810 **	0.1298		
sbi_34	0.3110 *	0.1789		
logemp2004	0.1314 **	0.0621		
sbi_52	-1.0236 ***	0.3107		
_cons	0.9631 ***	0.1300		

** p < 0.10, ** p < 0.05, *** p < 0.01*

Independent variables	Model 3b Coeff.	Robust S.E.		
sbi_15	0.4010 ***	0.1313	pseudo R2	0.0370
custcodum	0.4444 ***	0.0889	Log likelihood	-2502.32
suppcodum	-0.2345 ***	0.0848	Chi-squared	67.49
sbi_24	-0.2810 **	0.1298	observations	1581
sbi_52	-1.0236 ***	0.3107		
sbi_51	0.4878 ***	0.1315		
sbi_34	0.3110 *	0.1789		
logemp2004	0.1314 **	0.0621		
sbi_93	-1.0176	0.6493		
_cons	0.9631 ***	0.1300		

** p < 0.10, ** p < 0.05, *** p < 0.01*

Independent variables	Model 3c Coeff.	Robust S.E.		
geodivdum	0.6889 **	0.3509	pseudo R2	0.045
custcodum	0.3919 ***	0.0982	Log likelihood	-2493.5
suppcodum	-0.2689 **	0.0947	Chi-squared	73.95
compcodum	0.1605	0.1048	observations	1581
sbi_51	0.4805 ***	0.1281		
sbi_15	0.3935 ***	0.1301		
sbi_34	0.2825	0.1797		
logemp2004	0.1329 **	0.0632		
sbi_52	-1.0694 ***	0.3184		
sbi_23	-0.9648	0.6676		
abscap	0.2203 **	0.0969		
ad_geodiv	-0.6665 *	0.3572		
sbi_24	-0.2940 **	0.1323		
ad_scprco	-0.2193 **	0.1025		
sbi_93	-1.0022	0.6582		
_cons	0.8417 ***	0.1451		

** p < 0.10, ** p < 0.05, *** p < 0.01*

Innovation novelty 1 complete models

Independent variables	Model 4a Coeff.	Model 4a Robust S.E.	Model 4b Coeff.	Model 4b Robust S.E.	Model 4c Coeff.	Model 4c Robust S.E.
geodiversity	0.1992	0.1539	0.1497	0.1533	0.3483	0.2900
custcoop	0.2056 **	0.1048	0.2143 **	0.1043	0.2450	0.2066
suppcoop	-0.2305 **	0.0968	-0.2267 **	0.0963	-0.4237 **	0.1670
compcoop	0.0209	0.0898	0.0296	0.0896	-0.0179	0.1767
scprcoop	0.0008	0.1006	-0.0049	0.0997	-0.1588	0.1826
scpucoop	0.1330	0.1044	0.1097	0.1043	0.2154	0.1999
stakediversity	0.1769	0.3023	0.1462	0.3005	0.4181	0.5452
logemp2004	0.0152	0.0515	-0.0026	0.0517	-0.0012	0.0517
foreignmult	0.0674	0.0617	0.0760	0.0614	0.0689	0.0616
group	0.0060	0.2264	-0.0216	0.2282	-0.0197	0.2286
abscap			0.2410 ***	0.0638	0.2373 ***	0.0825
abs_geodiv					-0.2709	0.3309
abs_custco					-0.0436	0.2376
abs_suppco					0.3179	0.2030
abs_compco					0.0820	0.2039
abs_scprco					0.2413	0.2174
abs_scpuco					-0.1250	0.2348
abs_stakediv					-0.4833	0.6545
sbi_1	0.2438	0.2606	0.2757	0.2618	0.2790	0.2614
sbi_10	0.0509	0.3906	0.0424	0.3980	0.0529	0.3941
sbi_15	-0.0615	0.1619	-0.0624	0.1612	-0.0529	0.1614
sbi_17	0.0396	0.2215	0.0426	0.2171	0.0383	0.2180
sbi_21	-0.6000 ***	0.2344	-0.5992 ***	0.2336	-0.5985 ***	0.2334
sbi_22	-0.0274	0.2116	0.0001	0.2110	-0.0072	0.2095
sbi_23	-0.8502 *	0.4485	-0.8896 **	0.4258	-0.9350 *	0.4216
sbi_24	-0.2181	0.1691	-0.2288	0.1684	-0.2035	0.1694
sbi_25	0.0789	0.1824	0.0686	0.1818	0.0712	0.1814
sbi_27	-0.3681	0.3303	-0.3632	0.3303	-0.3874	0.3301
sbi_28	-0.0194	0.1769	0.0014	0.1765	-0.0119	0.1759
sbi_29	0.1314	0.1652	0.1078	0.1652	0.1149	0.1658
sbi_30	0.1896	0.1801	0.1669	0.1784	0.1603	0.1786
sbi_34	0.2831	0.2185	0.2691	0.2164	0.2696	0.2159
sbi_40	0.1139	0.3699	0.1592	0.3687	0.1607	0.3678
sbi_45	0.0589	0.1801	0.1057	0.1800	0.1149	0.1805
sbi_51	0.1031	0.1474	0.1511	0.1474	0.1471	0.1480
sbi_52	-0.0041	0.2690	0.0716	0.2698	0.0654	0.2690
sbi_55	-0.5132 **	0.2468	-0.4320 *	0.2480	-0.4312 *	0.2484
sbi_60	-0.2333	0.1842	-0.1763	0.1837	-0.1741	0.1852
sbi_65	-0.2447	0.2143	-0.1923	0.2131	-0.2048	0.2121
sbi_72	0.2326	0.1929	0.2214	0.1892	0.2205	0.1887
sbi_74	-0.0594	0.1545	-0.0204	0.1545	-0.0148	0.1546
sbi_80	-1.0932 *	0.6200	-0.9252	0.6157	-0.9060	0.6149
sbi_90	-0.4214	0.3395	-0.3467	0.3411	-0.3318	0.3429
sbi_93	-0.3388	0.4867	-0.3192	0.4783	-0.2892	0.4854
_cons	0.0556	0.2707	-0.0260	0.2734	-0.0224	0.2749
pseudo R2	0.019		0.022		0.022	
Log likelihood	-1881		-1873		-1871	
Chi-squared	89.95		103.73		107.69	
observations	1814		1814		1814	

** p < 0.10, ** p < 0.05, *** p < 0.01*

Innovation novelty 1 stepwise models

Independent variables	Model 4a Coeff.	Robust S.E.		
sbi_34	0.3521 *	0.1818	pseudo R2	0.017
custcoop	0.2762 ***	0.0758	Log likelihood	-1888.5
suppcoop	-0.1422 **	0.0716	Chi-squared	77.3
sbi_21	-0.5150 **	0.2017	observations	1814
sbi_29	0.2138 **	0.1102		
scpucoop	0.2461 ***	0.0724		
sbi_30	0.2654 **	0.1326		
sbi_72	0.2902 *	0.1489		
sbi_55	-0.4627 **	0.2149		
sbi_80	-1.0894 *	0.6222		
sbi_51	0.1888 **	0.0826		
sbi_23	-0.7921 *	0.4308		
_cons	0.0509	0.0472		

* p < 0.10, ** p < 0.05, *** p < 0.01

Independent variables	Model 4b Coeff.	Robust S.E.		
sbi_23	-0.8971 **	0.4102	pseudo R2	0.019
custcoop	0.2780 ***	0.0759	Log likelihood	-1881.39
suppcoop	-0.1608 **	0.0717	Chi-squared	89.45
sbi_51	0.1740 **	0.0822	observations	1814
sbi_80	-0.9715	0.6141		
scpucoop	0.2020 ***	0.0739		
sbi_55	-0.4363 **	0.2168		
sbi_21	-0.5911 ***	0.2017		
sbi_34	0.2612	0.1795		
sbi_72	0.2120	0.1442		
abscap	0.2680 ***	0.0624		
sbi_24	-0.2015 *	0.1145		
_cons	-0.0395	0.0577		

* p < 0.10, ** p < 0.05, *** p < 0.01

Independent variables	Model 4c Coeff.	Robust S.E.		
sbi_51	0.1740 **	0.0822	**pseudo R2**	0.019
custcoop	0.2780 ***	0.0759	**Log likelihood**	-1881.39
suppcoop	-0.1608 **	0.0717	**Chi-squared**	89.45
sbi_80	-0.9715	0.6141	**observations**	1814
sbi_23	-0.8971 **	0.4102		
scpucoop	0.2020 ***	0.0739		
sbi_55	-0.4363 **	0.2168		
sbi_21	-0.5911 ***	0.2017		
sbi_34	0.2612	0.1795		
sbi_72	0.2120	0.1442		
abscap	0.2680 ***	0.0624		
sbi_24	-0.2015 *	0.1145		
_cons	-0.0395	0.0577		

* p < 0.10, ** p < 0.05, *** p < 0.01

Innovation novelty 2 complete models

Independent variables	Model 5a Coeff.	Model 5a Robust S.E.	Model 5b Coeff.	Model 5b Robust S.E.	Model 5c Coeff.	Model 5c Robust S.E.
geodivdum	0.0644 **	0.0319	0.0502 *	0.0318	0.0554	0.0656
custcodum	0.0380 *	0.0213	0.0408 *	0.0214	0.0363	0.0454
suppcodum	-0.0449 **	0.0185	-0.0443 **	0.0185	-0.0415	0.0325
compcodum	0.0239	0.0178	0.0262	0.0177	-0.0235	0.0314
scprcodum	-0.0121	0.0194	-0.0142	0.0192	-0.0117	0.0316
scpucodum	0.0413 *	0.0225	0.0347	0.0223	0.0379	0.0344
stakedivdum	0.0181	0.0594	0.0104	0.0592	0.0366	0.1079
logemp2004	-0.0256 ***	0.0096	-0.0309 ***	0.0097	-0.0311 ***	0.0097
foreignmult	0.0128	0.0123	0.0157	0.0122	0.0160	0.0122
group	0.0221	0.0432	0.0133	0.0431	0.0128	0.0427
abscap			0.0699 ***	0.0129	0.0687 ***	0.0169
ad_geodiv					-0.0096	0.0717
ad_custco					0.0056	0.0507
ad_suppco					-0.0034	0.0387
ad_compco					0.0704 *	0.0382
ad_scprco					-0.0069	0.0398
ad_scpuco					-0.0068	0.0447
ad_stakediv					-0.0276	0.1300
sbi_1	0.0742	0.0604	0.0849	0.0611	0.0846	0.0598
sbi_10	-0.0123	0.0533	-0.0126	0.0529	-0.0101	0.0541
sbi_15	0.0038	0.0273	0.0035	0.0270	0.0028	0.0271
sbi_17	0.0162	0.0338	0.0156	0.0329	0.0128	0.0332
sbi_21	-0.0801 *	0.0413	-0.0799 *	0.0409	-0.0832 **	0.0408
sbi_22	0.0056	0.0347	0.0141	0.0341	0.0136	0.0342
sbi_23	-0.1045	0.0820	-0.1176	0.0764	-0.1172	0.0763
sbi_24	-0.0149	0.0286	-0.0182	0.0284	-0.0201	0.0286
sbi_25	0.0109	0.0281	0.0076	0.0278	0.0081	0.0280
sbi_27	-0.0589	0.0496	-0.0569	0.0499	-0.0574	0.0498
sbi_28	0.0159	0.0311	0.0222	0.0311	0.0206	0.0310
sbi_29	0.0670 **	0.0306	0.0607 **	0.0307	0.0597 *	0.0307
sbi_30	0.0526	0.0335	0.0456	0.0330	0.0450	0.0331
sbi_34	0.0887 **	0.0434	0.0846 **	0.0431	0.0843 **	0.0429
sbi_40	-0.0259	0.0463	-0.0125	0.0468	-0.0075	0.0478
sbi_45	0.0082	0.0288	0.0221	0.0288	0.0213	0.0288
sbi_51	0.0332	0.0259	0.0469 *	0.0260	0.0445 *	0.0260
sbi_52	-0.0485	0.0366	-0.0254	0.0370	-0.0265	0.0375
sbi_55	-0.0875 **	0.0405	-0.0629	0.0408	-0.0577	0.0411
sbi_60	0.0152	0.0382	0.0311	0.0382	0.0288	0.0384
sbi_65	0.0134	0.0471	0.0288	0.0471	0.0280	0.0468
sbi_72	0.1427 ***	0.0470	0.1384 ***	0.0457	0.1370 ***	0.0455
sbi_74	0.0076	0.0264	0.0196	0.0264	0.0197	0.0264
sbi_80	-0.1700	0.1151	-0.1213	0.1139	-0.1255	0.1163
sbi_90	-0.0875 *	0.0465	-0.0651	0.0474	-0.0653	0.0487
sbi_93	-0.0536	0.0731	-0.0490	0.0709	-0.0455	0.0735
_cons	-0.0282	0.0493	-0.0510	0.0492	-0.0482	0.0493
pseudo R2	0.043		0.053		0.054	
Log likelihood	-436.43		-420.83		-419.19	
Chi-squared	103.75		117.82		120.93	
observations	1814		1814		1814	

** p < 0.10, ** p < 0.05, *** p < 0.01*

Innovation novelty 2 stepwise models

Independent variables	Model 5a Coeff.	Robust S.E.		
geodiversity	0.0654 **	0.0305	pseudo R2	0.040
custcoop	0.0402 **	0.0158	Log likelihood	-440.285
suppcoop	-0.0431 ***	0.0152	Chi-squared	95.64
compcoop	0.0242	0.0168	observations	1814
sbi_34	0.0837 **	0.0388		
scpucoop	0.0412 **	0.0175		
sbi_52	-0.0551 *	0.0310		
logemp2004	-0.0269 ***	0.0092		
sbi_51	0.0299 *	0.0176		
sbi_30	0.0490 *	0.0275		
sbi_72	0.1364 ***	0.0432		
sbi_80	-0.1794	0.1139		
sbi_29	0.0617 ***	0.0239		
sbi_55	-0.0933 ***	0.0361		
sbi_21	-0.0845 **	0.0367		
sbi_90	-0.0970 **	0.0422		
_cons	0.0059	0.0204		

* p < 0.10, ** p < 0.05, *** p < 0.01

Independent variables	Model 5b Coeff.	Robust S.E.		
geodiversity	0.0607 *	0.0312	pseudo R2	0.049
custcoop	0.0415 ***	0.0157	Log likelihood	-425.974
suppcoop	-0.0476 ***	0.0157	Chi-squared	104.78
compcoop	0.0240	0.0166	observations	1814
sbi_51	0.0316 *	0.0177		
scpucoop	0.0311 *	0.0174		
sbi_90	-0.0880 **	0.0432		
logemp2004	-0.0322 ***	0.0092		
sbi_24	-0.0331	0.0212		
sbi_23	-0.1292 *	0.0765		
abscap	0.0702 ***	0.0128		
sbi_27	-0.0712	0.0461		
sbi_72	0.1203 ***	0.0416		
sbi_29	0.0427 *	0.0245		
sbi_55	-0.0800 **	0.0365		
sbi_21	-0.0968 ***	0.0365		
sbi_34	0.0671 *	0.0386		
_cons	-0.0132	0.0204		

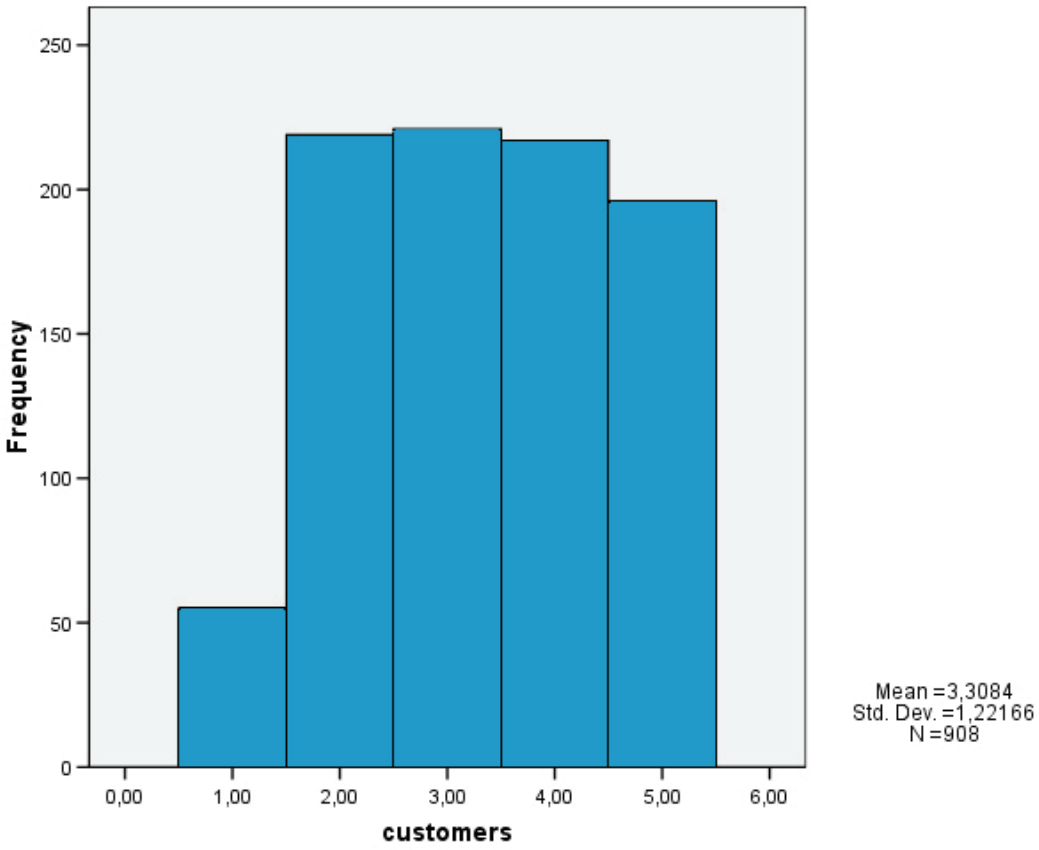
* p < 0.10, ** p < 0.05, *** p < 0.01

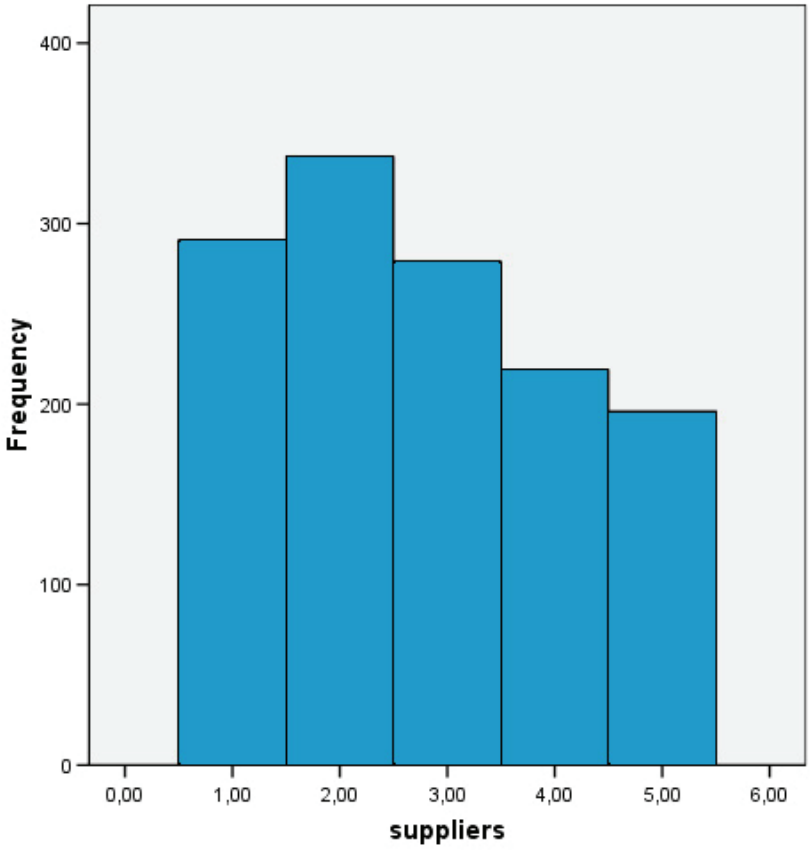
Independent variables	Model 5c Coeff.	Robust S.E.		
geodiversity	0.0583 *	0.0312	pseudo R2	0.051
custcoop	0.0419 ***	0.0154	Log likelihood	-424.846
suppcoop	-0.0461 ***	0.0156	Chi-squared	105.31
sbi_23	-0.1280 *	0.0765	observations	1814
sbi_24	-0.0338	0.0212		
scpucoop	0.0284	0.0174		
sbi_90	-0.0870 **	0.0433		
logemp2004	-0.0325 ***	0.0092		
sbi_34	0.0677 *	0.0384		
sbi_51	0.0306 *	0.0177		
abscap	0.0640 ***	0.0130		
sbi_29	0.0421 *	0.0244		
sbi_27	-0.0697	0.0459		
sbi_21	-0.0994 ***	0.0363		
abs_compco	0.0404 **	0.0203		
sbi_55	-0.0770 **	0.0366		
sbi_72	0.1204 ***	0.0416		
_cons	-0.0090	0.0205		

* p < 0.10, ** p < 0.05, *** p < 0.01

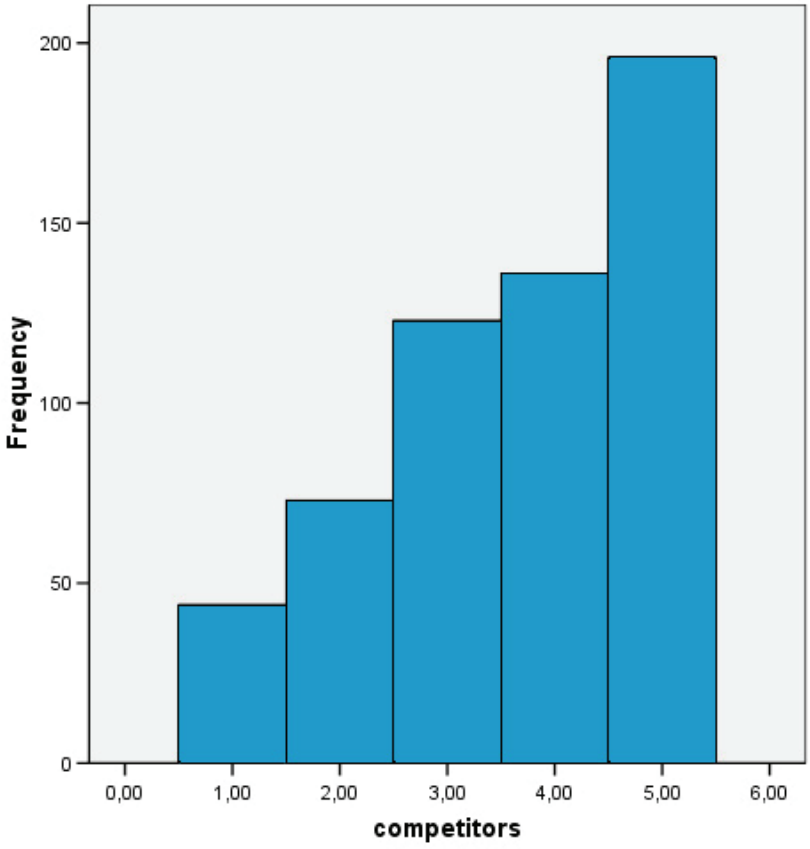
Appendix G: Plots of amount of cooperation per partner type

These plots show the distribution of how many types of stakeholders an organization is partnered with, when this organization is partnered with a certain type of stakeholder. Interesting to notice is that when an organization is partnered with suppliers, it is not unlikely that the partnership with suppliers is the only type of partnership. This is in strong contrast with the other stakeholder type of partners where it is by far most likely that the focal organization is also engaged in cooperation with other types of stakeholders.

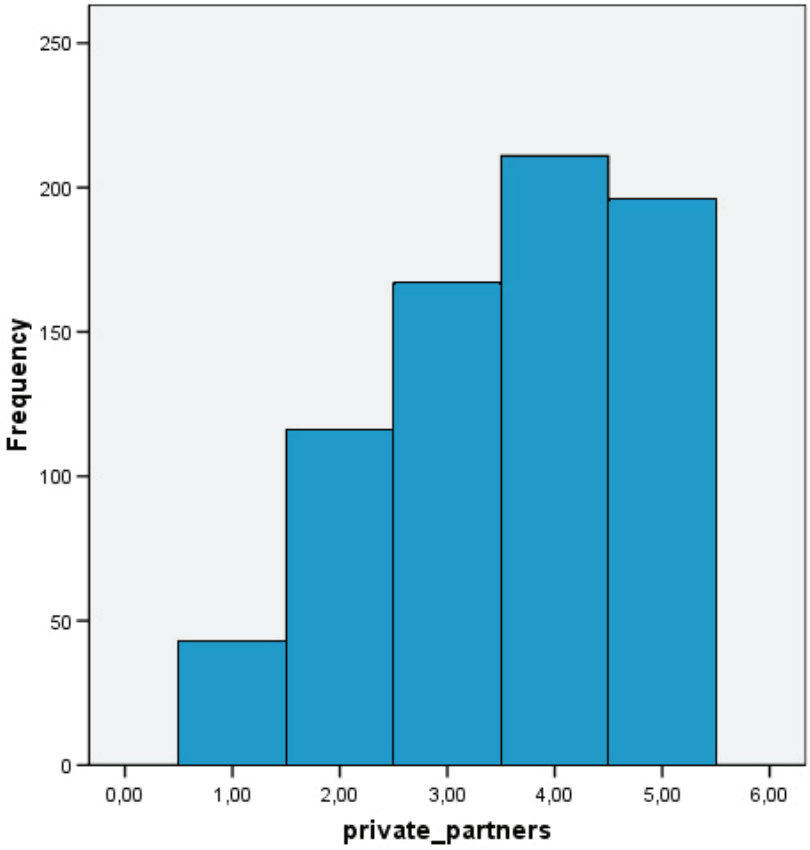




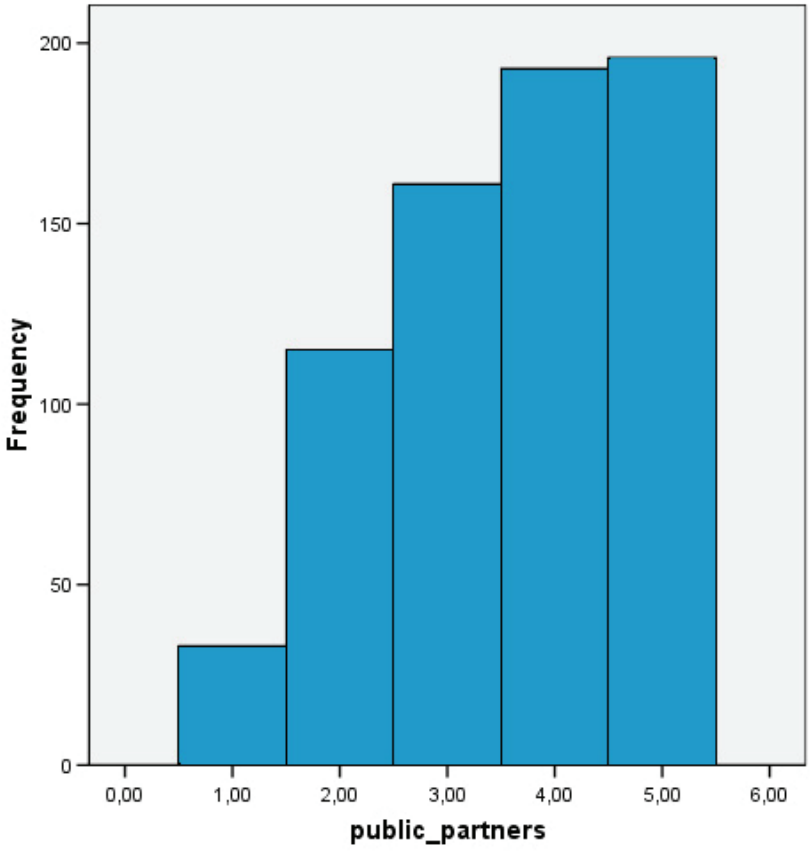
Mean =2,767
Std. Dev. =1,35691
N =1.322



Mean =3,6416
Std. Dev. =1,27863
N =572



Mean =3,5471
Std. Dev. =1,20542
N =733



Mean =3,5788
Std. Dev. =1,19189
N =698