Innovation und Technologie im modernen Management
Hrsg.: Dieter Wagner und Dana Mietzner

Juliane Hartig

Learning and Innovation @ a Distance

An Empirical Investigation into the Benefits and Liabilities of Different Forms of Distance on Interactive Learning and Novelty Creation in German Biotechnology SMEs

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RESEARCH

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Innovation und Technologie im modernen Management

Herausgegeben von /
Edited by
Prof. Dr. Dieter Wagner und Dr. Dana Mietzner

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With a foreword by Prof. Dr. Dieter Wagner

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Foreword

Within the paradigm of 'Open Innovation', there is an increase in network-like, international forms of collaboration. This is also true for small and medium-sized firms in the area of research and development meaning that 'Global Open Innovation' is expanding over large geographic distances.

Certainly, geographic proximity is an important precondition of interactive collaboration; however, Innovation Research increasingly finds that this is neither a necessary nor sufficient precondition. Finally, inter-organizational collaboration can also take place in a virtual environment. Against this background, it is commendable that Ms. Hartig has investigated both qualitatively and quantitatively, the possibilities and barriers of 'distance' and 'proximity' from the point of view of different dimensions and categories based on 39 cooperation projects by German biotechnology SMEs, and has herewith broken new ground.

Ultimately, this dissertation is about the research question; how different forms of distance influence interactive learning in inter-organizational co-operation projects in R&D in order to generate effective innovation. With regards to the management of inter-organizational cooperation, it turns to the question of how, despite great 'distances', a sufficient level of 'proximity' can be established. This is an intriguing question which will, doubtless, enrich Innovation Research to a great extent.

Meritoriously, the author addresses a theme that is not only highly complex but also topically relevant. Against the research background, her empirical investigation is methodologically consistent. The theoretical foundation is sound as are the proper deduction of hypotheses and the apt interplay of quantitative and qualitative research.

With particular regard to the developed process model of inter-organizational cooperation and the degree of influence as well as partial interplay of different forms of distance, Ms. Hartig has derived interesting findings which will, doubtless, stimulate further research. Therefore, this dissertation deserves broad dissemination.

Prof. Dr. Dieter Wagner

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Preface

Thanks to my Parents and Matthias,
you provided the best support imaginable.

I have written this thesis during my affiliations at the University of Potsdam, at the Fraunhofer Institute for Systems and Innovation Research (ISI), and at the University of Manchester (Manchester Institute for Innovation Research, MIoIR).

Many people, to who I am indebted, have accompanied and supported me along the way: Professor Dr. Dieter Wagner, Professor Dr. Knut Blind, Professor Jakob Edler, Professor Philippe Larédo, Dr. Thomas Reiss, Professor Dr. Sibylle Gaisser, and many others.

Juliane Hartig

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List of Abbreviations

BRIC **B**razil, **R**ussia, **I**ndia, **C**hina

CEO **C**hief **E**xecuting **O**fficer

CFO **C**hief **F**inancial **O**fficer

COO **C**hief **O**perating **O**fficer

CSO **C**hief **S**cientific **O**fficer

e.g. for example

EUR **Eur**o

i.e. that is

ICT **I**nformation and **c**ommunication **t**echnologies

IP **I**nterview **p**artner

M&A **M**erger and **A**cquisition

MNE **M**ulti**n**ational **e**nterprise

NGO **N**on-**g**overnmental **o**rganisation

NIH **N**ot **i**nvented **h**ere

NSH **N**ot **s**old **h**ere

OLS **O**rdinary **L**east **S**quares

PRO **P**ublic **r**esearch **o**rganisation

R&D **R**esearch and **D**evelopment

RbV **R**esource **b**ased **V**iew

SME **S**mall and **m**edium sized **e**nterprise

SNP **S**ocial **N**etwork **P**erspective

TCE **T**ransaction **C**ost **E**conomics

UK **U**nited **K**ingdom

USA **U**nited **S**tates of **A**merica

1 Introduction

1.1 Background

This thesis builds on contemporary observations of a qualitative change in the way research and development (R&D), invention and innovation activities take place:

- *an increasingly open, distributed or network-like character of innovation activities with the locus of innovation shifting from an individual entrepreneur to hybrids, consortia or networks* (Bouba-Olga & Grossetti, 2007; Laursen & Salter, 2006; Chesbrough, 2006, 2003; Powell & Grodal, 2005; Gassmann & Enkel, 2005; Coombs et al., 2001; Powell & Brantley, 1992);
- *an increasing geographic reach of innovation activities*, and a geographic topography best characterised as *'local nodes in global networks'* (Belussi et al., 2010; Cooke, 2008; Moodysson, 2008; Coenen, 2006; Asheim & Gertler, 2005; Bathelt et al., 2004). Increasingly, innovation activities take place on different geographic scales, combining the best of local resources and expertise with global ones. Moreover, geographic scope has broadened from the traditional research countries (North America, Canada, Europe and Japan) to newcomers, particularly Russia, India, China and, to a lesser extent, Brazil (the BRICs) (Boekholt et al., 2009; Howells, 2008; UNCTAD, 2005).

Both developments combined have lately been described as 'Global Open Innovation' (Herstad et al., 2008; OECD, 2008). Global Open Innovation is perceived as an important strategy for firms' sustained competitiveness in a 'globalising learning economy' (Archibugi & Lundvall, 2001). Moreover, particularly on the in-bound side[1], it is perceived as a viable way for small and medium sized firms (SMEs) to participate in the global exploration and exploitation of knowledge (OECD, 2008).[2]

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[1] Open Innovation is defined as 'the use of purposive in-flows and out-flows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation, respectively' (Chesbrough, 2006, p. 1). Thus, it comprises in-bound as well as out-bound activities, or combinations of both (Gassmann & Enkel, 2005).

[2] The OECD (2008) report reads as follows: 'The internationalisation of innovation requires a level of investment and resources that smaller companies typically do not possess. ... Open

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Global Open Innovation can take different forms. From the point of view of SMEs, and focusing on in-bound activities, global participation includes indirect forms (such as tapping local universities that are integrated into international networks; the reading of international publications; the licensing of knowledge, or the hiring of foreign employees) and more immediate forms of participation (such as co-operation with international partners or greenfield investments abroad) (van der Vrande et al., 2009; Edler, 2007).

In recent decades, the number of inter-organisational co-operation agreements in R&D, and particularly *international* co-operation agreements, has increased considerably (Giuri et al., 2006; Guellec & Pottelsberghe, 2001; Hagedoorn, 2002; Narula & Hagedoorn, 1999). Moreover, more flexible forms, such as inter-organisational projects, came to dominate equity investments, such as joint ventures or minority stakes (Hagedoorn, 2002; Narula & Hagedoorn, 1999). This development is in line with a broader trend toward the use of more temporary, flexible organisational forms as found in inter- as well as intra-organisational projects (Oerlemans & Pretorius, 2010; Janowicz-Panjaitan et al., 2009; Sydow et al., 2004).

In particular in R&D, the range of knowledge bases and resources necessary for invention and innovation is constantly expanding in both breadth, i.e., the number of relevant disciplines, and depth, i.e., their sophistication and specialisation, which no single firm can provide internally (Wang & von Tunzelmann, 2000). Thus, inter-organisational co-operation today primarily covers the combination of knowledge and resources, usually through project-based groups of engineers and scientists from each organisation (Hagedoorn, 2002). Specifically, *international* co-operation offers firms opportunities to draw upon knowledge and skills that are not available in their home country and to realise more radical innovation by integrating knowledge from different areas of science and technology. Besides, firms seek to share the costs for capital investment, such as laboratories, office space and equipment, as well as the risks from R&D, to shape competition, set standards, conform to government policies or enter new markets (Narula, 2004; Nooteboom, 2004b; Nummela, 2003; Lubatkin et al., 2001; Glaister & Buckley, 1996).

innovation may however provide an answer to the challenge of globalisation (of innovation) for smaller companies. It may offer (especially on the in-bound side, i.e., the sourcing of knowledge and technology) a less costly alternative to local R&D facilities for obtaining rapid access to local centres of knowledge across the world. Open innovation may speed up the internationalisation of innovation in smaller (high-technology) companies if they do not need to set up full-scale R&D facilities locally' (p. 33).

Despite high degrees of dissatisfaction[3], inter-organisational co-operation is now perceived as a preferred governance form, allowing firms of all sizes fast and flexible access to knowledge and skills across the globe that they perceive to be valuable (Narula, 2004; Narula & Hagedoorn, 1999; Dunning, 1995).

However, high degrees of dissatisfaction demonstrate that inter-organisational co-operation, particularly on a global level, poses high challenges. Moreover, their upsurge obscures the canonical view from innovation studies, stressing the meaning of the home nation or region and thus geographic and institutional proximity for effective interactive learning and novelty generation (Asheim & Gertler, 2005; Koschatzky, 2001; Brown & Duguid, 2000; Cooke et al., 1997; Lundvall, 1988).[4] Accordingly, interpreting their findings of a high share of non-local co-operation, Giuri et al. (2006) state that 'surprisingly, interaction with geographically close individuals in other organizations is the *least* important form of collaboration. This is puzzling given the emphasis in the literature on the importance of geographical proximity for collaboration and knowledge transfer' (p. 16, italics in the original). Thus, it seems that the 'external reality' (Lawson, 1988, p. 54) has outpaced theory building.

[3] Existing studies report high degrees of dissatisfaction with the outcomes of inter-organisational co-operation (e.g., Peng & Shenkar, 2002; OECD, 2000; PWC, 2000; Bleeke & Ernst, 1993). The study by PWC (2000) is particularly insightful: in a survey of 184 pharmaceutical firms from mostly North America and Europe, of which more than 40% were SMEs, they found a high share of co-operative agreements that did not live up to initial expectations. This is particularly prevalent in collaborative research (with 64% of co-operation agreements not meeting expectations), and in collaborative development (with 60%). Moreover, the study reveals that the reasons for failure are by and large within management control, whereas technical feasibility as a source for failure ranked significantly lower. In descending order, the following reasons for failure were indicated by the respondents: expected results slow to materialise; differences in partner cultures; changes in management; weak commitment; poor leadership, and poor communication. Particularly at an international level, the challenges inherent in inter-organisational co-operation are amplified (Johanson & Vahlne, 2009; Olson et al., 2009; Sirmon & Lane, 2004).

[4] This view builds on Lundvall (1988) who suggests that 'the selective user-producer relationships will involve units more or less distant from each other in geographical and cultural space' (p. 354) and underscores the supportive role of geographical and cultural proximity, particularly in the case of complex technologies, fast technical pace, or in the case of the emergence of new technological paradigms. Koschatzky (2001, pp. 53 ff.) gives two reasons: first, tacitness of knowledge and a lack of codes call for face-to-face exchanges and thus geographic proximity; second, being cognitively constrained, actors seek for new information in their vicinity. Both reasons are seized later in the discussion on the role of different forms of distance for interactive learning and novelty generation (see Chapter 4).

With network strategies proliferating and stretching across different geographic scales, new questions arise, such as: What is the specific role of geographic proximity, particularly in the view of new means for electronic information and communication? What characterises distant ties? And, more generally, are international co-operation projects a viable option for SMEs to participate in global knowledge networks in order to explore new knowledge domains or exploit their knowledge, or are the 'liabilities of distance' too great to realise the benefits? How can firms effectively and efficiently leverage external knowledge and skills, not only across geographic but also across organisational, institutional and technological distance? This thesis seeks to find answers to some of these questions.

This introductory chapter proceeds as follows: section 1.2 outlines the aim of the thesis, discusses the research gap and provides a summary of key research questions. The research design is introduced in section 1.3, together with the presentation of the organisation of the book. Finally, section 1.4 provides an outline of concepts and definitions that are central to the thesis.

1.2 Aim, Research Gap, and Research Questions

Seizing these questions, *the overarching aim of this thesis is to analyse whether and under what constellations 'Global Open Innovation' in the form of international inter-organisational co-operation projects constitutes a viable option for SMEs to participate directly in the global generation and exploitation of knowledge and innovation, or whether there exist 'liabilities of distance' that outweigh the benefits.*

One recent line of research that scrutinises these developments – increasingly open innovation processes and increasing local–global innovation dynamics – and their implications for organisations, regions and innovation policy has opted for the existence of different forms of proximity that underpin and shape interactive learning and novelty generation. This research is grounded upon an understanding of proximity not only in a narrow, literal sense of a geographic metric, but in a wider and differentiated understanding integrating different forms of socio-economic or socio-cognitive proximity. For proponents of this view, geographic space is at most a blanket dimension or indirect moderator that needs to be filled with socio-economic relations and their characteristics.

This understanding of different forms of proximity has been forwarded by a French research group, named 'French School of Proximity Dynamics' or 'Economics of Proximity' (Carrincazeaux et al., 2008). While this group, initially composed of regional innovation and industrial economics scholars, mostly focuses on regional dynamics and the advantages of proximity relations, newer contributions – particular those from an innovation perspective – highlight the benefits of distant relationships for their heightened learning and novelty potential (Boschma & Frenken, 2009; Meder, 2008; Boschma, 2005a). Thus, the concept has become increasingly popular and spread more widely into different areas of research. Knoben and Oerlemans (2006) qualify this line of reasoning as 'an important emerging concept in several fields of science, for example in innovation studies, organisation science and regional science' (p. 71).

However, comprehensive, systematic research that sticks to this conceptual clarity and puts this on a thorough empirical ground is lacking to date. Despite finding increasing appeal in the literature, contemporary contributions have mostly been of a conceptual nature (e.g., Knoben & Oerlemans, 2006; Boschma, 2005a; Bouba-Olga & Grossetti, 2005; Torre & Rallet, 2005; Rallet & Torre, 1999a,b; Kirat & Lung, 1999; Bellet et al., 1993). A small number of empirical contributions so far have concentrated on a subset, mostly one or two forms of proximity (e.g., Broekel & Boschma, 2009; Meder, 2008; Ponds et al., 2007; Agrawal et al., 2006; Breschi & Lissoni, 2006; Nooteboom et al., 2006; Mowery et al., 1998). Moreover, these contributions have primarily investigated the role of different forms of proximity to *form* collaborative ventures, not their *impact* on interactive learning and novelty generation; i.e., on the course and outcomes of inter-organisational co-operation (Balland, 2009; Broekel & Boschma, 2009; Meder, 2008). Furthermore, most studies depart from a national or regional lens and aim to explain regional dynamics and regional cohesion (e.g., Boschma & Frenken, 2009; Boschma, 2005a; Rallet & Torre, 1999b). Yet, the explanatory framework likewise contributes important insights into centrifugal forces; i.e., forces that explain international interaction and networks. So far, contributions in this direction have been entirely exploratory, qualitative studies (Lorentzen, 2008; Moodysson, 2008, 2007; Moodysson & Jonsson, 2007; Asheim & Gertler, 2005; Zeller, 2004). In these studies, searching 'beyond the local' – again in different forms – is thought to be an important, however so far under-explored, lever for learning and novelty generation.

Hence, this thesis adopts an innovation perspective and investigates the benefits and liabilities of different forms and expressions of distance between co-operation partners in international projects (Boschma & Frenken, 2009; Rosenkopf & Nerkar, 2001).[5] To go one step further, the implications for managing international co-operation projects have never been taken into account. From the perspective of SMEs, this notion of different forms of distance or proximity that underpin interactive learning and novelty generation is thought to contribute valuable insights into the benefits and challenges of global participation.

Therefore, the following research question is central to the aim of this thesis: *How do different forms of distance alone and together influence interactive learning and novelty generation in international inter-organisational co-operation projects in R&D? And how can management organise a requisite level of proximity within inter-organisational co-operation projects?* This question has been broken down into a number of operational questions that guide the theoretical and empirical part of the thesis (table 1.1).

Theoretically, this contribution is supposed to advance the emerging view of different forms of proximity, respectively distance, their role, interplay and consequences thereof for the global participation of SMEs. Practically, it serves to channel the awareness of the people involved in inter-organisational co-operation projects to those factors that are conducive or critical, to guide their decision-making and to provide suggestions for organising inter-organisational co-operation projects. Doing this, it focuses on the particularities of knowledge-based SMEs.

[5] Somewhat related are previous studies investigating 'partner fit' in inter-organisational co-operation along various dimensions, such as strategic, organisational, cultural or technological (e.g., Ermisch, 2007; Child et al., 2005; Specht et al., 2002). However, 'partner fit' can be qualified as a rather static view that is – although contributing important insights on success factors for co-operation in general – less insightful to explain the two faces of interactive learning and novelty generation in inter-organisational R&D: novelty potential on the one hand and integration challenges on the other.

Table 1.1: Research Questions

1	**Distant relationships: Characteristics, effects and interplay**
1.1	Which forms of distance shape the process of interactive learning and novelty generation in inter-organisational co-operation projects in R&D?
1.2	What reach do international inter-organisational co-operation projects in R&D have in regard to different forms of distance?
1.3	What is the impact of different forms of distance for interactive learning and novelty generation in inter-organisational co-operation projects?
1.4	Which forms of distance matter (most) and why in regard to the course and outcome of inter-organisational co-operation in R&D; i.e. interactive learning and novelty generation?
1.5	What role does geographic distance play (in the context of other forms of distance, respectively proximity) for interactive learning and novelty generation in inter-organisational projects? Are there any further interaction effects between different forms of distance?
2	**Role of intermediating variables**
2.1	Are there any differences in the impact of different forms of distance in regard to different stages in the invention process?
2.2	Are there any differences in the impact of different forms of distance in regard to different learning rationales?
3	**Conclusions for management**
3.1	How can management respond to organise proximity in relevant dimensions of distance?
3.2	Are there any differences for management in regard to intermediating variables (invention stage, learning rationale)?

1.3 Research Design and Organisation of the Book

This thesis consists of a theoretical and an empirical part. The **theoretical part** begins with a discussion of current theories of the firm and its boundaries; these provide key rationales for inter-organisational co-operation, but at the same time define their risks and challenges (Chapter 2). Based on this, Chapter 3 explores the process of interactive learning and novelty generation and defines key challenges and requirements in this process. Together, Chapters 2 and 3 introduce the main building blocks for the discussion of the role of different forms of distance for interactive learning and novelty generation, which follows in Chapter 4. Based on a comparison and combination of existing taxonomies, a conceptual framework of six forms of distance is devised, consisting of a geographical, institutional, organisational, strategic, technological and relational form. Based on this framework, a differentiated discussion of the benefits and liabilities of the different forms of distance for interactive learning and novelty generation follows. The theoretical part closes with an elaboration of hypotheses that guide the empirical part (Chapter 5).

To reduce the heterogeneity of the sample, the empirical analysis concentrates on German biotechnology SMEs as the central **research setting**. Starting in the mid-1990s, biotechnology now constitutes a valuable industry in Germany, with over 500 dedicated biotechnology firms, mostly SMEs, registered in Germany in 2009 (Biocom, 2010).[6] The reasons for the selection of this industry and its characteristics are outlined in Chapter 6.

Chapter 7 introduces the methodology for the **empirical part**, which investigates the impact and interplay of different forms of distance for interactive learning and novelty generation. The unit of analysis constitutes an international inter-organisational project in R&D, which is delineated and defined in section 1.4. The aim is to probe the so-far conceptual debate empirically and to explore key mechanisms, effects and managerial responses. This twin task integrates elements from deductive as well as inductive research. Thus, the empirical part of the thesis follows a retroductive research rationale, which combines elements from deductive and inductive research (Downward & Mearman, 2007; Sæther, 1998; Ragin, 1994). The notion of a close coupling of ideas from theory and the 'external reality' (Lawson, 1988, p. 54) as proposed by Ragin (1994) is best suited to realise the research agenda of the thesis and to come to profound conclusions regarding the impact and management of distant relationships.

Methodologically, the empirical investigation combines elements from quantitative and qualitative research. In the literature, this combination of methods is referred to as a 'mixed method approach', which is becoming increasingly popular in empirical studies (DeCuir-Gunby, 2008; Teddlie & Tashakkori, 2003a; Creswell, 2003, 1999).

[6] According to the OECD, a 'dedicated biotechnology firm' is defined as 'a biotechnology active firm whose predominant activity involves the application of biotechnology techniques to produce goods or services and/or the performance of biotechnology R&D' (OECD, 2005b, p. 10). Excluded from the empirical sample are diversified companies, such as multinational pharmaceutical companies.

Creswell (1999) provides the following definition of a mixed method approach: 'A mixed-method study is one in which the research uses at least one quantitative and one qualitative method to collect, analyse and report findings in a single study' (p. 457). This combination follows the rationale that 'a phenomenon is best understood if it is viewed from various perspectives' (DeCuir-Gunby, 2008, p. 125). This research strategy is particularly suited for a retroductive research rationale (Downward & Mearman, 2007).

Following this research strategy, primary data is collected based on a semi-structured interview guideline that integrates both closed- and open-ended questions. In this way, quantitative and qualitative data is collected simultaneously that is used for numeric as well as non-numeric evaluation.

The data is analysed and presented in two separate steps. First, an *extensive*, cross-case, *field study* serves to evaluate the (relative) impact and interplay of different forms of distance for interactive learning and novelty generation (Chapter 8). The quantitative data from the interviews is evaluated using multivariate analysis techniques. The interpretation of the results draws on the qualitative data collected within the personal interviews. Second, this extensive study is followed up by an *intensive study* in the form of selected case studies to illustrate the impact of distance in different co-operation constellations and to gain insights into how management can respond to them by organising proximity (Chapter 9). For this step, more secondary data, as found in press releases, annual reports, home pages and commercial databases, is integrated.

The key findings and implications of the thesis, for both theory and practice, are drawn in Chapter 10. The thesis concludes with a final discussion of the contribution and limitations of the thesis and a proposal of potential avenues for future research (Chapter 11). Figure 1.1 provides an overview of the organisation of the thesis.

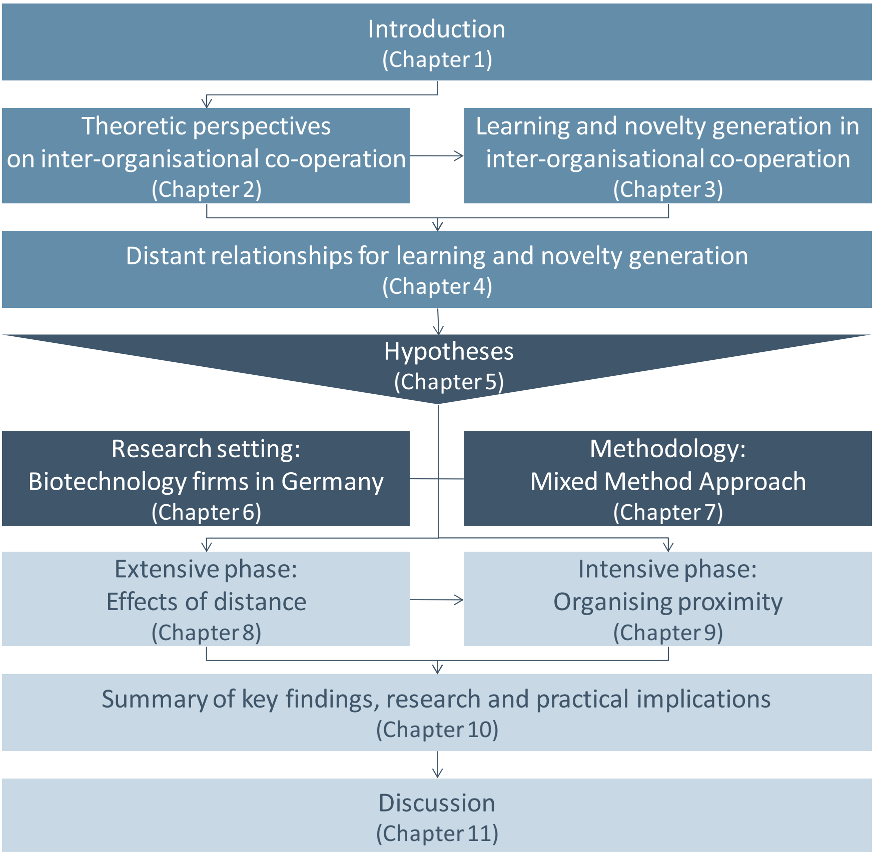

Figure 1.1: Organisation of the Thesis

1.4 Concepts and Definitions

In recent years, a variety of forms of co-operation between organisations have emerged. These encompass relatively low-investment, market-like forms (technical assistance, patent licensing, networks without a central co-ordinator); co-operative forms (joint projects, alliances, equity joint ventures), and more integrated forms (networks with a central hub or franchising contracts) (Inkpen, 2000; Narula & Hagedoorn, 1999; Gerybadze, 1995; Contractor & Lorange, 1988).[7] Figure 1.2 provides an overview of the most common forms of inter-organisational co-operation on a continuum from market through to integrated solutions. Thus, 'inter-organisational co-operation' is used as an umbrella term that needs thorough specification in the light of this multiplicity of inter-organisational co-operation forms (Inkpen, 2000).[8]

Inter-organisational co-operation is defined as the productive combination of resources and capabilities across organisational boundaries to achieve a common purpose. Müller (2003) distinguishes between *constitutive* and *differentiating* elements in defining and delineating co-operation from other organisational forms. The constitutive elements are:

- the legal autonomy of the partners while their economic activities are at least temporarily and to some extent inter-dependent, and
- the explicitly agreed upon pooling of resources and co-ordination of activities towards (a) shared goal(s).

These two constitutive elements are necessary conditions for the existence of some form of inter-organisational co-operation. However, there is still a multiplicity of co-operative forms subsumed under this definition (see figure 1.2). To define and specify the unit of analysis more narrowly, common differentiating criteria are the *number of co-operation partners*, the *types of partners*, *differences in size among the partners*, their *position vis-à-vis each other in the value chain*, the *origins of the partners*, its *legal form*, *time horizon*, as well as the *function in the value*

[7] Narula and Hagedoorn (1999) observed that it is particularly non-equity agreements that increased in use over the last two decades; foremost driven by the intent to jointly undertake research and development in high-technology and fast-evolving sectors (see section 1.1).

[8] In this thesis, the term 'inter-organisational co-operation' is often used as an umbrella term. Only in cases where specification is needed or reference to particular literature is used, the term is specified or the term used by the respective authors is adopted.

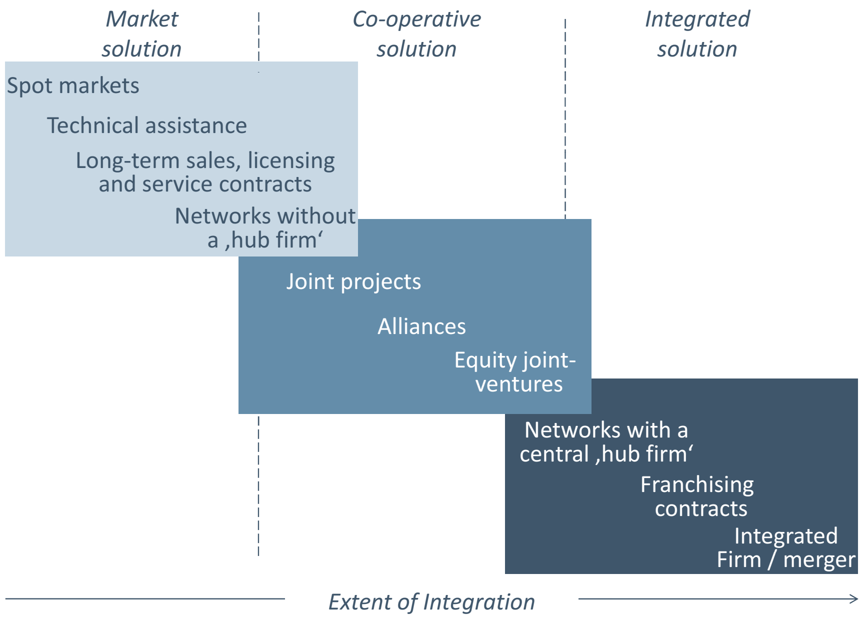

Figure 1.2: Alternative forms of co-operation (adapted from Gerybadze, 1995, p. 74)

chain concerned (Ermisch, 2007; Scholl, 2006; Müller, 2003). Moreover, the phase in the *co-operation cycle* has been added here. Conceptually, the cited authors refer to morphological boxes to visually delineate their unit of analysis. A respective morphological box is presented in figure 1.3. The elements characterising the object of analysis in the prospective study are shaded in dark colour.

Specifically, this thesis investigates **bilateral**, or dyadic[9], relationships. However, these relationships are perceived as being situated within and shaped by broader networks of relationships (see section 2.4). Accordingly, the thesis draws on and refers at various stages within the argument to social network literature. Networks constitute 'a set of nodes (e.g., persons, organisations) linked by a set of social relationships (e.g., friendship, transfer of funds, overlapping membership) of a specified

[9] 'Dyad' is an expression from network analysis. It constitutes the 'smallest unit of network analysis. It is a network which consists of only two elements; i.e., it consists of two elements and their relationship' (Jansen, 1999, p. 54, own translation).

<table>
<tr><th>Dimension</th><th colspan="6">Characteristics</th></tr>
<tr><td>Number of partners</td><td colspan="3">bilateral (dyad)</td><td colspan="3">multilateral (network)</td></tr>
<tr><td>Types of partners</td><td colspan="2">firms</td><td colspan="2">universities, other public research organisations</td><td colspan="2">governmental / non-governmental bodies</td></tr>
<tr><td>Differences in size</td><td colspan="3">same</td><td colspan="3">different</td></tr>
<tr><td>Position in the value chain</td><td colspan="3">vertically</td><td colspan="3">horizontally</td></tr>
<tr><td>Origins of the partner</td><td colspan="2">local, regional</td><td colspan="2">national</td><td colspan="2">international</td></tr>
<tr><td>Legal form</td><td colspan="2">non- contractual</td><td colspan="2">contractual</td><td colspan="2">equity</td></tr>
<tr><td>Time horizon</td><td colspan="3">temporary</td><td colspan="3">enduring</td></tr>
<tr><td>Co-operation cycle</td><td>initiation</td><td colspan="2">planning</td><td colspan="2">operation</td><td>exit</td></tr>
<tr><td>Function of the value chain</td><td colspan="2">R&D</td><td colspan="2">production</td><td colspan="2">marketing, sales</td></tr>
</table>

Figure 1.3: Characterisation of the Object of Analysis

type' (Gulati, 1998, p. 295, referencing Laumann et al. 1978, p. 458). That is, networks are not only perceived as business networks linking organisations, but as any type of relational links between organisations or individuals.

Co-operation **partners** can be firms, public or private research organisations, or non-governmental as well as governmental organisations. Furthermore, the partners can be of the same or different **sizes**; they can be **positioned** vertically or horizontally vis-à-vis each other in the value chain. They can be suppliers, customers, competitors or unrelated organisations.

Moreover, this thesis investigates **international** co-operation, to explore whether global participation is a valuable option for SMEs and to analyse how geographic distance impacts on the co-operation. International co-operation implies a combination of resources and capabilities between two organisations that are headquartered in two different nation-states and where the respective team members operate in different nations (Parkhe, 1991, p. 581).

In regard to the **legal form**, the extremes of either informal, non-contractual co-operation as well as equity investments such as joint ventures are excluded. Instead, the thesis concentrates on inter-organisational projects which are contractually fixed.

Projects are commonly depicted as temporary organisational forms that are becoming more and more popular for solving particular problems within and across organisations and as an 'ideal loci of learning and innovation' (Bakker & Janowicz-Panjaitan, 2009, p. 121; Oerlemans & Pretorius, 2010; Janowicz-Panjaitan et al., 2009; Sapsed & Salter, 2004; Sydow et al., 2004; Zeller, 2002; Sydow & Windeler, 1999). For Sydow et al. (2004), 'projects as temporary systems refer to groups comprising a mix of different specialist competences, which have to achieve a certain goal or carry out a specific task within limits set as to costs and time' (p. 1480). For them, this characterisation is 'informative of the transient and multidisciplinary nature of projects – features that fundamentally contribute to shaping the possibilities as well as the obstacles for generating knowledge and accumulating learning' (p. 1480). Thus, key characteristics of projects are their temporariness (transient nature), mix of specialties (multidisciplinarity), goal orientation, resource limitations and their orientation toward knowledge generation and learning. Müller (2003) adds uncertainty and high expectations as further characteristics of projects. These characteristics define the challenges and pressures that inter-organisational projects are subject to.

Inter-organisational co-operation typically follows distinct stages in a **co-operation life cycle**, comprising the phases of initiation (including partner search and selection), planning, operation and exit (figure 1.4). This thesis concentrates on the process of interactive learning and novelty generation, and hence on the operation of the co-operation project. As existing studies that apply the concept of various forms of proximity, respectively distance, for learning and novelty generation have concentrated on partner search and selection, this thesis closes an existing research gap, which is also generally observed in regard to contemporary research on inter-organisational co-operation (Faulkner & de Rond, 2000).

Figure 1.4: Phases of a co-operation project (adapted from Müller, 2003, p. 23)

Centrally, this thesis concentrates on co-operation in **research and development** (R&D). Following the OECD definition, research and development is understood as 'any creative systematic activity undertaken in order to increase the stock of knowledge' (OECD, 2003). R&D is commonly further distinguished into basic research, applied research and development. According to Grupp (1998, pp. 11 ff.), **basic research** refers to 'experimental or theoretical work that is geared "primarily" to the generation of new knowledge ... without targeting a particular application or use'. **Applied research** likewise serves to generate new knowledge; however, it is 'biased towards specific and practical purposes or objectives'. **Development** is 'systematic work structured on existing knowledge ... which is directed towards the production of new materials, products, equipment or the installation of new processes, systems or services'.

R&D – particularly in the realm of firms – is not an end in itself. It serves to generate **innovation**. There exists no unified definition of innovation (Hauschildt, 2007; Burr, 2004). Most authors depart by referencing Schumpeter (1997) and his rather pragmatic definition of innovation as the 'implementation of new combinations' (p. 101). Grupp (1998) distinguishes between innovation as a noun, or an outcome, and innovation as a verb or process: 'As a noun, innovation relates to an attained quantity of ideas', while 'as a verb, to innovate denotes the relevant development process (innovation process)' (p. 13). Innovation as an outcome can materialise in the form of new goods, methods, markets, organisational forms and the like. Not dismissing the fact that there are also other forms of innovation, this thesis focuses mainly on knowledge-based or technological innovation in the form of new or enhanced products or technologies (Specht et al., 2002; Grupp, 1998).

Moreover, innovation as an outcome is often characterised by its degree of novelty, distinguishing between the extremes of radical or revolutionary and incremental or evolutionary innovation. However, a clear distinction between the two is often difficult in real-life phenomena (Burr, 2004). It also depends on the perspective adopted, be it from the micro perspective of a firm or the macro perspective of technological progress. Thus, Burr (2004) adds that innovation is not subject to pure objective measurement, but contains subjective evaluations.

In regard to innovation as a process, Pavitt (2005, p. 88) highlights two central characteristics:

- Innovation processes involve the exploration and exploitation of opportunities for new or improved products, processes or services, based either on an advance in technical practice ('know-how'), or a change in market demand, or a combination of the two.
- Innovation is inherently uncertain, given the impossibility of accurately predicting the cost and performance of a new artifact, and the reaction of users to it.[10] It therefore involves processes of learning either through experimentation (trial and error) or improved understanding (theory).

Another important distinction, investigating the process of innovation more narrowly, is often made between invention, innovation and diffusion (Fagerberg, 2005; Burr, 2004; Specht et al., 2002). The term **invention** comprises the first technical realisation of a new product, process or service as well as the novel combination of scientific insights. It is usually the outcome of R&D activities or serendipitous events or insights. **Innovation (in a narrow sense)** spans a broader process of carrying ideas out into practice, usually comprising the implementation, production and/or market introduction of a new product, process, service or organisational form (Burr, 2004; Specht et al., 2002).[11] **Diffusion** finally comprises the broader acceptance and adoption of the innovation within the firm or on the market, and is often followed by imitation through competitors. Sometimes, all three steps, invention, innovation and diffusion are summarised under the umbrella term of innovation (in a broad sense, see figure 1.5).[12]

[10] Pisano (2010) adds the uncertainty of basic technological feasibility as characteristic for science-based industries.

[11] Likewise, the OECD (2005b) definition of innovation reads as follows: 'Innovation is the *implementation* of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relation' (p. 46, emphasis added by the author).

[12] It needs to be taken into account that this process is neither purely sequential, nor determinative, but tends to proceed in loops or in parallel (Burr, 2004; Grupp, 1998; Kline, 1995; Kline & Rosenberg, 1986). Yet, for the purpose of defining and delineating the research object, this presentation is instrumental.

Strictly speaking, the outcome of a successful co-operation project in R&D needs to be qualified as an invention, although the subsequent up-scaling and commercial launch can be part of the inter-organisational agreement; however, this is not the focus of the current analysis (Burr, 2004; Grupp, 1998). The focus of the current analysis is delineated by a dashed line in figure 1.5. For simplicity, the term 'novelty generation' (rather than 'implementation') is used in this thesis to describe the process toward the desired end product of a successful co-operation project in R&D.

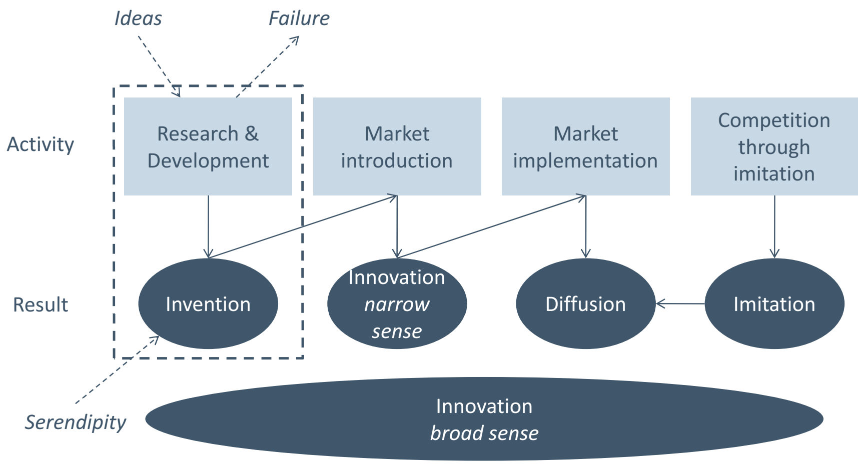

Figure 1.5: The Innovation Process (adapted from Burr, 2004, p. 28, referencing Brockhoff 1999, p. 38)

It is commonly accepted that the generation of novelty often occurs in the form of 'novel combinations' (Schumpeter, 1997, p. 100).[13] Moreover, it is currently suggested that more radical combinations tend to arise from contacts with actors

[13] Invention and innovation can also result from the 'alertness' of an entrepreneur who is quick at realising profits from market disequilibria in offer and needs (Kirzner, 1979). Being alert in the meaning of finding and exploiting previously unexploited opportunities or needs can be an important impetus for inter-organisational R&D. Although Schumpeter describes a disequilibrating activity while in Kirzner's view disequilibira are the source for innovation, both types of entrepreneurship can constitute rationales for inter-organisational co-operation. Thus, innovation is rather perceived as a 'collusion between needs and opportunities', a notion forwarded by Lundvall (1992, p. 50).

outside the organisation who have developed their own resources and cognition and who are also in a better position to challenge existing perspectives (Schoenmakers & Duysters, 2010; Lam, 2005; Rosenkopf & Nerkar, 2001). This heightened novelty potential from external combinations of resources and cognition is an important assumption of the current rise in open or distributed innovation processes (Teixeira et al., 2008; Chesbrough, 2006, 2003; Gassmann & Enkel, 2005; Powell & Grodal, 2005; Coombs et al., 2001; Coombs & Metcalfe, 1998; von Hippel, 1988).

This assumption about the potential sources for innovation is closely related to the current research into **diversity**. Diversity is perceived as a broad concept, referring to 'the presence of differences among members of a social unit' (Jackson et al., 1995, p. 217). Others go further to include similarities next to differences in their definition of diversity (Wagner & Sepehri, 2000; Thomas, 1996). These differences or similarities can include various dimensions, some of which are more overt and explicit (e.g., gender, age, nationality, ethnic group), while others are more latent and subtle (e.g., values, personality, knowledge and expertise) (van Knippenberg et al., 2004). Moreover, diversity is interpreted as a subjective and perceptual construct. As such, the perception of difference is submit to dynamic processes of perceptual changes and adaptations (van Knippenberg et al., 2004; Ely & Thomas, 2001). Diversity as found in groups or teams is currently seen as a potential wellspring for learning and novelty generation, as well as a source of friction or disruption, with current empirical studies providing mixed results on the positive as well as negative effect of diversity on group outcomes (Bouncken & Winkler, 2010; Köppel, 2007; van Knippenberg et al., 2004; Jehn et al., 1999; Pelled et al., 1999).

Furthermore, joint R&D activities entail **learning** processes, understood as the generation, acquisition and accumulation of knowledge on an individual or collective level (Lam, 2005; Child et al., 2005; Argyris & Schön, 1996).[14] Child et al. (2005, pp. 275 ff.) identify four forms of learning accruing in inter-organisational co-operation:

[14] Argyris and Schön (1996) respond to the discussion of whether organisations or only individuals learn. Here, their conclusion is followed that collective learning, however based on individual learning and adaptation processes, can take place; e.g., in the development of new routines that are collective patterns of activity. What is important is that it is always individuals who are involved in learning processes.

- *learning from experience*, entailing general co-operation experience;
- *learning about a partner*, which comprises partner-specific co-operation experience and constitutes a relation-specific asset;
- *learning from a partner*, which involves the 'movement of existing knowledge into a different organisational setting', and
- *learning with a partner*, which implies the 'creation of *new* knowledge, or at least a *substantial transformation* of existing knowledge'.

Similarly, Lubatkin et al. (2001) distinguish between 'knowledge absorption alliances' (p. 1360), which corresponds to learning from a partner, and 'reciprocal learning alliances' (p. 1362), which relates to learning with a partner. Reciprocal alliances aim to create new knowledge through a blending of existing knowledge, where each partner specialises on his knowledge. Although all four forms of learning constitute important forms of learning in inter-organisational co-operation, the latter two forms are under scrutiny in this investigation of inter-organisational co-operation in R&D with the purpose to create science-based, technological innovation. Thus, when talking about learning, the latter two forms are meant, otherwise specific reference to different forms of learning is made.

The discussion so far has displayed the pre-eminent role of **knowledge** within R&D, invention and innovation, and as an organisational asset more generally. Machlup (1980) adopts a broad conception of knowledge, stating that 'anything that people think they know I include in the universe of knowledge' (p. xiii). Davenport and Prusak (1998) are more specific in their definition, defining knowledge as 'a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information' (p. 5). What both definitions have in common is a constructivist view of knowledge, being based on a personal perception of what is true and what is known. Besides, most contributions distinguish knowledge from data and information. While data constitutes the raw codes and symbols, these can be turned into structured pieces of information that convey messages to an addressee or an audience. This information can be processed and become meaningful by using one's existing knowledge (mental categories, schemes of interpretation); at the same time, it can increase the stock of individual knowledge (Lundvall, 2006; Amin & Cohendet, 2004; Davenport & Prusak, 1998). Another important insight is the distinction between tacit and explicit knowledge based on the work of Polanyi (1958). Polanyi observes that large parts of knowledge that underpin (day-to-day) skills are tacit in the sense that the knowledge holder is either:

- not aware of his knowledge and skills, which work at the background of his consciousness, or
- not able to articulate his knowledge and skills, although he is generally aware of their existence (Gertler, 2003; Nelson & Winter, 1982, in reference to Polanyi 1966).

However, in most current contributions, the stringent view of tacit knowledge as a purely background knowledge that cannot be overtly expressed, is relaxed. Instead, a continuum of knowledge characteristics is offered with some bodies of knowledge being inherently tacit, while others are principally expressible, but not readily available or only available at considerable costs, and again others are found in an immediately codified, accessible form (Balconi et al., 2007; Hull & Andiani, 2003).

This ties into the typology provided by Lundvall and Johnson (1994) and Johnson et al. (2002), who distinguish between 'know-why', 'know-what', 'know-how', and 'know-who'. 'Know-why' and 'know-what' is characterised by rather formal, or declarative, knowledge about facts, principles and laws of nature, whereas the 'know-how' and 'know-who' are strongly based on procedural knowledge (skills), personal experience as well as social relationships. It is here that large parts of knowledge have a tacit component. However, these knowledge types mostly do not exist in their 'pure' forms. Thus, Johnson et al. (2002) acknowledge that 'there may be a "know-how" dimension to our use of even basic forms of "know-why" ' (p. 251). Vice versa, 'in fields characterized by intense technological competition, technical solutions are often ahead of academic know-why. In these cases technology can solve problems or perform functions without a clear scientific understanding of why it works' (p. 252).

While neither the tacit/codified complex nor the different types of knowledge defined by Lundvall and Johnson (1994) are clearly distinct types, the internalisation of knowledge as being at least partly tacit and subjective as well as often embodied and crafts-like is important for an understanding of knowledge as a key organisational resource, as well as a rationale for inter-organisational co-operation.

Furthermore, this thesis concentrates on **knowledge-** or **science-based SMEs**. In line with the definition provided by the European Commission, SMEs are delineated by one of the following criteria: a maximum of 250 people employed; an annual turnover of equal to or less than 50 million Euros, or a balance sheet total of up to 43 million Euros (EC, 2009). Further, Pisano (2010) defines science-based firms as 'entities that both participate in the creation and advancement of science and attempt to capture financial returns from this participation. They are not simply "users" of science, but contributors to it as well' (p. 471), which distinguishes science-based from high-technology firms.

Arnold and Thuriaux (1997) summarise central characteristics of SMEs: by definition equipped with fewer resources (financially, manpower), SMEs can allocate fewer resources to each venture. There are generally higher opportunity costs for each investment and false investments weigh relatively higher, eventually setting the survival of the firm at risk. Consequently, SME managers are often described as risk-averse. Furthermore, Arnold and Thuriaux suggest that a ' "professional" management' (p. 9) is often lacking, particularly as it is difficult to create a requisite division of labour and develop specialised interfaces. As a result, management operates in a 'vicious cycle of overwork' (p. 9), which they suggest lead to a general inability to fully consider and exploit external opportunities. It has also been assumed that knowledge is more tacit in SMEs; i.e., it is more bound to individuals and less formalised in manuals (Nooteboom, 2004b). Narula (2004) surmises that 'although SMEs continue to have the advantages of flexibility and rapid response, the traditional disadvantages due to size limitations may have worsened due to the demand for multiple technological competence and by increased competition' (p. 153). This situation calls for more intense and frequent co-operation with outside partners. However, the disadvantages due to size limitations – often referred to as 'liabilities of smallness' – pose considerable hurdles to inter-organisational co-operation strategies. This thesis takes these characteristics into account and focuses on the distinct needs and challenges of science-based SMEs.

2 Theoretic Perspectives on Inter-Organisational Co-operation

2.1 Overview

Generally, there exists no single, holistic theory, but a multiplicity of strands which are either alone or in combination used to explain and characterise inter-organisational co-operation (Child et al., 2005; Faulkner & de Rond, 2000; Sydow, 1992). Many of these theoretical strands concentrate on very narrow questions or on rather stable (vertical) relationships between organisations. Thus, they are not well suited to generate an understanding for interactive learning and novelty generation in temporary inter-organisational projects.[1]

[1] From an economic viewpoint, Market Power Theory, Transaction Cost Theory, Agency Theory, Game Theory, Real Options Theory and Resource based View offer different perspectives on inter-organisational co-operation (Child et al., 2005). While Market Power Theory (Porter & Fuller, 1986) contributes motives for inter-organisational co-operation (e.g., to raise entry barriers or set standards), it has not been central to explain interactive learning and novelty generation in inter-organisational arrangements. Agency Theory focuses on how to efficiently devise organisational governance structures, given divergent interests and asymmetric information between principal and agent. Thus, it informs on the efficient design of governance structures, not on rationales to engage in co-operation, particularly in processes of interactive learning and novelty generation (Burr, 2004; Eisenhardt, 1989b). Moreover, it is based on similar behavioural assumptions as Transaction Cost Economics, which is discussed in section 2.2. Game Theory is concerned with behavioural tactics of organisations and individuals entering into exchange relationships, particularly in situations of co-opetition (Brandenburger & Nalebuff, 1996; Schrader, 1990; Axelrod, 1984). Hence, it concentrates on a very specific question. The discussion in section 4.4.4 on the effects of strategic distance draws on these insights. Adopted from finance, Real Options Theory provides an additional motive to engage in co-operation, particularly in R&D: 'real options are especially valuable for projects that involve both a high level of uncertainty and opportunities to dispel it as new information becomes available' (Copeland & Keenan, 1998, p. 128). Yet, this is consistent with the rationale to access resources as proclaimed by the Resource based View, which is a central point of reference in the thesis (see section 2.3).

In addition to economic theories, management and organisational theories, such as Resource Dependence Theory, Organisational Learning and Social Network Perspectives are used to explain inter-organisational co-operation (Child et al., 2005). Resource

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Central theories that deliver important insights on the characteristics, benefits, challenges and risks of interactive learning and novelty generation in inter-organisational co-operation are: Transaction Cost Economics (TCE), the Resource based View (RbV) and the Social Network Perspective (SNP).

Transaction Cost Economics and the Resource based View have come to be perceived as connected building blocks of a general theory of the firm as well as inter-organisational co-operation (Narula & Santangelo, 2007; Ermisch, 2007; Amin & Cohendet, 2004; Foss & Foss, 2004; Colombo, 2003; Mellewigt, 2003; Madhok, 2000; Tallman, 2000; Antlitz, 1999). While Transaction Cost Economics focuses on efficiency and underscores relational risks, the Resource based View stresses differences in resource endowments of organisations. Thus, it concentrates on the benefits of combining different resources of distinct organisations, which is perceived to be conducive to learning and novelty generation. Besides, the latter view has subsequently included insights from organisational learning and cognitive theories, which provide an important additional rationale in a dynamic analysis of learning and novelty generation. In particular, an excursus is made to introduce one recent offspring of the Resource based View, called a 'Cognitive Theory of the Firm' (Nooteboom, 2009).

As third line of theory, social theory and network analysis – here together referred to as Social Network Perspective – has gained in popularity in recent years; in particular to explain interactive learning and novelty generation. It contributes an alternative, complementary perspective to organisational behaviour, explaining important antecedents, processes and outcomes of inter-organisational co-operation (Gulati et al., 2000; Gulati, 1995a,b). It is currently perceived that a neglect of these social factors and network structures yields a biased view on inter-organisational co-operation (Granovetter, 1985).

Dependence Theory (Pfeffer & Salancik, 1978) is close to the Resource based View in stressing access to external resources. However, it addresses organisational dependencies in stable, long-term relationships which oppose the transient nature of co-operation projects geared toward interactive learning and novelty generation. Moreover, this thesis adopts central ideas from Organisational Learning theory (Argyris & Schön, 1996) in the discussion of the Resource based View (section 2.3). The Social Network Perspective is discussed in section 2.4. Another strand, which is particularly pronounced in Germany following Sydow (1992), are system theoretical and contingency views on co-operation (e.g., Eggers, 2004). However, Sydow (1992, p. 214) acknowledges that many existing studies pursue a contingency perspective, without making it explicit which likewise applies for this thesis. Others, e.g. political theories (see Sydow, 1992), are beyond the scope of this thesis as they likewise not contribute to explain processes of interactive learning and novelty generation.

In sections 2.2, 2.3 and 2.4, each of these theories is discussed along the lines: (1) its basic assumptions and general tenets; (2) its contribution to explain inter-organisational co-operation, focusing on interactive learning and novelty generation in R&D projects; followed by (3) an assessment of its contributions, limitations and possible extensions. The most important insights for this study are summarised in section 2.5.

2.2 Transaction Cost Economics

Transaction Cost Economics (TCE) is one of the oldest yet most prevalent theories on organisational boundary decisions. Despite the emergence of newer theories, it stands the test of time, highlighting important facets of organisational behaviour and boundary decisions which contribute to explain the benefits and challenges of inter-organisational co-operation (Macher & Richman, 2008; Osborn & Hagedoorn, 1997).[2] It is not inherently construed to explain interactive learning and novelty generation; however, it yields important insights on organisational behaviour and the kinds of risks to be expected from inter-organisational co-operation in R&D.

Basic Assumptions and Point of Departure

In the early 1930s – a time when economists praised markets for their efficiency to align offer and demand – Ronald Coase set off to answer the question why not all economic transactions are left to markets and the price mechanism as co-ordination device, but why and when firms emerge as alternative governance forms. And vice versa, if firms turn out to have advantages over market transactions, then why are not all transactions carried out within the confines of one big firm (Coase, 1937)?

Coase (1937) built his answer to these questions on two basic behavioural assumptions: agents are perceived as boundedly rationale as well as inclined to opportunistic

[2] Assessing the current state of TCE in empirical research in the social sciences, Macher and Richman (2008) provide evidence on the constantly increasing application and spread of TCE in different academic fields over the period from 1976 until 2004. Particularly the category 'others' which comprises publications in the areas of innovation, international business, organisational behaviour (among which the study of inter-organisational co-operation is a key driver), and business history, display the second highest growth rates.

behaviour. They are not omniscient and the costs of finding and processing all relevant information to evaluate a market transaction and attach a price to it can be high. However, this is perceived as necessary, given the expectation of opportunistic behaviour of the transaction partner. Thus, actors will strive to minimise their vulnerability by engaging in searches for information which leads to additional costs of using the market, so-called transaction costs. These costs vary with certain characteristics of a transaction, which are (i) the frequency with which a transaction occurs; (ii) the degree of uncertainty to which actors are subject, and (iii) conditions of asset specificity, i.e., whether assets can be redeployed to alternative uses and by alternative users without sacrifice of their value. High asset specificity of a transaction can lead to a situation of small numbers bargaining in any later period of interaction and 'bilateral dependency' (Williamson, 1991, p. 271). Finally, it is the conjunction of these behavioural assumptions and the respective task characteristics that determines the additional costs of using the price mechanism, i.e., the respective transaction costs (Williamson, 1975).

Furthermore, different kinds of transaction costs occur in different stages of the exchange relationship. Williamson (1973) refers to the costs incurred in the 'original negotiation' (p. 317) stage, often referred to as ex ante transaction costs of searching for information and establishing contracts, and the costs occurring during the stage of 'contract execution and renewal' (p. 317), more commonly referred to as ex post transaction costs of executing, monitoring and adapting, as well as enforcing contracts.

Under certain circumstances, firms can sacrifice high transaction costs by internalising the transaction within the firm. Thus, when transactions are one-off, uncertainty and asset specificity are low, market transactions are deemed to be the preferred transaction form. Under such conditions, the market backed by the law of contract provides sufficient safeguards to the partners. By contrast, when transactions are recurrent or take long to materialise, have highly uncertain outcomes and require transaction-specific investments, a hierarchy constitutes the more efficient governance form. The main legal basis within hierarchies are employment contracts, which allow for control and direction to realise a transaction (Macher & Richman, 2008; Child et al., 2005; Williamson, 1991, 1975). On the other hand, firm size is also limited due to 'diminishing returns to management' (Coase, 1937, p. 395).

TCE and Inter-Organisational Co-operation in R&D

Coase (1937) merely distinguished between the two alternative governance forms market and hierarchy. 'Hybrid forms' of governance, i.e. inter-organisational co-operation, were only later included, especially by Williamson (1991, 1985). In his book from 1985, *The economic Institutions of Capitalism*, Williamson introduces four possible governance modes: markets, trilateral governance, bilateral governance and hierarchies. Trilateral governance implies that market contracts should be mediated by third-party assistance, whereas bilateral, or relational contracting, builds on long-term investments between the transaction partners. Trilateral and bilateral governance forms constitute hybrid governance structures, positioned intermediate between markets and hierarchies.

In his 1991 paper, Williamson systematically analyses the characteristics of hybrid governance forms, explaining the differences of each governance form in regard to the contract law they are submit to, the degree and kind of adaptability they offer and their respective use of incentive and control mechanisms. Specifically, market transactions rely on classical contract law which can be fully specified and enforced through courts. Hybrids by contrast resort to neo-classical contracting, where each party maintains autonomy, but becomes also dependent on the other in the filling of the contract. Constituting rather a framework contract, a neo-classical contract is more open to adaptations, and arbitration joins legal litigation in the case of conflict. Lastly, hierarchies resort to fiat and forbearance, which is operated in more long-term employment contracts, where disputes are settled outside the court and where 'hierarchy is its own court of ultimate appeal' (p. 274). Thus, 'neoclassical contract law of hybrid governance differs from both the classical contract law of markets and the forbearance contract law of hierarchies, being more elastic than the former but more legalistic than the latter' (p. 280).

Next, the criterion adaptability covers two forms: first, autonomous adaptation to prices as achieved on the market, and second, bilateral adaptation where 'convergent expectations' (p. 278) among the parties are necessary to achieve co-ordinated responses, which can only be achieved through hybrids or hierarchy. This is particularly necessary when the gaps arising from incomplete contracts need to be filled.[3]

[3] According to Morroni (2006), 'incomplete contracts are due to incomplete and heterogeneous knowledge of the possible outcomes (substantive radical uncertainty) or incomplete information-processing ability (procedural radical uncertainty) that generates incomplete

In this case, independent adaptations would eventually yield imperfect alignments and could 'operate at cross-purposes' (p. 279).

Lastly, in market relations, actions and consequences can be linked, leading to high incentives to conform. Other forms of governance are less transparent in this respect. On the other hand, hierarchies offer administrative controls, such as monitoring and career rewards and penalties, which align interests and suppress deviating behaviour. Being submit to neoclassical contracting, where the parties retain their autonomy, hybrids retain incentives to some degree, but also allow for some level of control, e.g., in the form of information disclosure, although with a more limited set of instruments compared to hierarchies. Thus, hybrid governance modes display intermediate values in all criteria (see table 2.1).

Table 2.1: Distinguishing Attributes of Markets, Hybrids and Hierarchies (Williamson, 1991, p. 281)

	Governance structure		
Attributes	Market	Hybrid	Hierarchy
Instruments			
Incentive intensity	++	+	0
Administrative controls	0	+	++
Performance attributes			
Autonomous adaptation	++	+	0
Bilateral adaptation (co-operation)	0	+	++
Contract law	++	+	0
++ = strong; + = semi-strong; 0 = weak			

Again, depending on the characteristics of the transaction – frequency of interaction, uncertainty and asset specificity – different advantages are offered by markets, hybrids or hierarchies. Typically, R&D projects, defined in section 1.4 as a knowledge-based, inherently uncertain, as well as temporary activity, display the following characteristics.

forecasting about the other party's behaviour' (p. 160). Both types of uncertainties are likely to exist in inter-organisational co-operation in R&D.

Uncertainty (incomplete contracts):

- Ex ante problems of evaluation: R&D centers on knowledge, an individual and tacit good, which is particularly hard to evaluate and attach market prices to it. It might be required that one or both partners reveal important parts of their knowledge ex ante, which is often supposed to be their key asset. Opportunistic agents might then use this information without paying the price for it (Hennart, 1988, referencing Arrow, 1962). On the other hand, knowledge as opposed to information cannot be easily transferred and absorbed, which implies either even higher investments in knowledge sharing to allow ex ante evaluation, or else a higher level of uncertainty remaining within the transaction. Either solution increases the vulnerability of the transaction partners.

- Incomplete contracts: R&D is an inherently uncertain activity and the contributions by the parties, the path the project takes, as well as the final results are often not fully predictable (Pavitt, 2005). Uncertain process steps, outcomes and frequent adaptations impede the full specification of contracts (Tripsas et al., 1995). Nooteboom (2009, 1999) and also Becker (2004) add that full specification of contracts is even not desirable in R&D as it leads to a straitjacket for the researchers that impedes their creativity and flexibility to generate novelty. Together, this results in incomplete contracts and eventually greater leeway for opportunistic behaviour (Hagedoorn et al., 2000).

- Ex post problems of evaluation: R&D is about the generation of new knowledge, products, processes or services. As the results of R&D activities are mostly not fully predictable and there exists no benchmark to compare them, they are hard to evaluate. In case a project fails, this might be due to technical failure, unfavourable external conditions, lack of commitment by the parties, deficiency in knowledge and skills, or purposeful betrayal (Nooteboom, 2009; Tripsas et al., 1995; Hennart, 1988). However, there is hardly any measure to distinguish between them, reveal and sanction opportunistic behaviour.

Asset specificity:

- In R&D, a situation of 'small numbers bargaining' is likely to exist from the outset as it is assumed that the market for potential partners is rather thin with few alternatives existing (Becker, 2004). Even more, joint learning and mutual specialisation processes within the co-operation can increase the asset specificity in any later period after initial contracting (Nooteboom, 1999; Tripsas et al., 1995; Pisano, 1991). These investments are partner- and task-specific, and thus eventually useless in other constellations ('uses') and for other partners ('users'), leading to a 'fundamental transformation' (e.g., Williamson, 2003, p. 14) of the market.

Frequency:

- To jointly affect R&D, i.e., to share and create (foremost tacit) knowledge, frequent interactions between the partners are necessary, calling for more intimate relationships than market transactions offer (Tripsas et al., 1995). On the other hand, an inherent characteristic of a project is its transient nature, which argues against full internalisation of the transaction (see section 1.4).

While the first four reasons raise concerns about the efficiency of a market transaction, the fifth reason argues against the costs of full internalisation of the task (Kenis et al., 2009). Following Williamson (1991), under a hybrid governance structure, both partners have more control and insight into how much effort each partner is expending; at the same time, bilateral adaptations are possible, while holding up the incentives for each to contribute. This argument favours hybrid structures under neo-classical contracts for temporary projects in R&D. However, the remaining leeway that they offer also entails relational risks. Thus, some researchers adopt a critical stance, expecting high transaction costs and relational risks from co-operation in R&D and question their stability (Becker, 2004; Swoboda, 2003; Faulkner & de Rond, 2000; Tripsas et al., 1995; Lundvall, 1992; Williamson, 1991; Buckley & Casson, 1988).

In regard to knowledge-based SMEs, it needs to be considered that their expertise often centers on highly specific, tacit or new knowledge which increases the partner's difficulties to assess its value. Conversely, SMEs are more prone to relational risks, lacking the means and bargaining power to enforce their rights (Nooteboom, 1999; Tripsas et al., 1995). Compared to large firms, a loss weighs relatively higher and eventually sets the whole business at risk.

Contributions, Limitations and Possible Extensions

The discussion has yielded important insights into behavioural assumptions, characteristics of knowledge as exchange good and the nature of hybrid contracts. Allowing for mutual adaptations and some level of control while retaining incentives, hybrid governance forms can be suited to cope with inter-organisational projects in R&D. On the other hand, incomplete contracts which need to be filled and adapted during the co-operation can constitute a source of relational risks and conflict.

Besides, some more critical points are expounded below which highlight the limits and possible extensions of TCE. According to Williamson (1979), 'the overall objective of the exercise essentially comes down to this: for each abstract description of a transaction, identify the most economical governance structure' (pp. 234-235). This analytical simplicity at the same time results in one fundamental shortcoming: the framework cedes with defining central attributes of the *transaction* which help to determine the most *efficient* governance solution, but disregards its *content* and *effectiveness* (Nooteboom, 2009). However, in a competitive and dynamic environment marked by quality leadership and innovation, the maximisation of effectiveness is an equally important – if not more rewarding – strategy which might at times justify higher transaction costs. Similarly, Eisenhardt and Schoonhoven (1996) purport that, by looking solely at the attributes of a transaction, TCE 'does not capture many of the strategic advantages of alliances' (p. 137).

TCE – although an attempt has been made to integrate interactive learning and novelty generation into the framework – is a traditionally static approach which focuses on the exchange of *existing* goods or services in *stable* environments. Thus, it has not been developed to explain the joint *creation* of resources in a *dynamic* environment. Similarly, Lundvall (1992) criticises TCE for representing an equilibrium theory concentrating on calculation und decision-making instead of learning and innovation.[4]

Moreover, in today's network ecology, co-operation is claimed to follow its own rationale, detached from being positioned as an alternative governance form on a

[4] Also Williamson (1985) critically acknowledges that 'the study of economic organisation in a regime of rapid innovation poses much more difficult issues than those addressed here [within TCE, comment by the author]' where 'new hybrid forms of organisation may appear in response to such a condition' (pp. 143-144).

continuum between market and hierarchy (Williamson, 1991; Sydow, 1992). Affiliated to this critique is also the rejection of the assumption of free choice among alternative governance forms and their substitutability. Yamin (1996) states that 'for organisational choice to exist, it is necessary that the transaction does not change as it is shifted from one organisational mode to another. ... If the main reason for co-operation between two firms is inter-firm learning, then only organisational arrangements that can allow effective communication of firm-specific and hence implicit knowledge can be considered for the governance and management of such a relationship. This limits organisational choice and could conceivably rule it out altogether' (p. 166).

Besides, TCE adopts a rather simplistic view in respect to its behavioural assumptions. Particularly, a new interest in the existence, constituents and forms of trust and social relations in economic interaction has questioned the extent of opportunistic behaviour (Kale & Singh, 2000). It is suggested that actors can govern their behaviour and choose among the most appropriate conduct from trustworthiness to opportunism (Lubatkin et al., 2001). Moreover, bilateral transactions tend to take place under the institutions of wider networks of relationships that define social norms of conduct and deter their members from acting opportunistically (see section 2.4).

2.3 Resource Based View

The Resource based View (RbV) of the firm aims to explain the constituents and the (limits of) growth of a firm as well as firm boundary decisions from a different perspective, turning to the internal constituents and strategic outlook of the firm. Since the early 1990s, there has been a shift in the literature on strategic management, away from industrial economics-driven views such as the Market based View which adopt an outside-in perspective to an insight-out perspective which focuses on firm-internal resources and capabilities as key determinants of firm competitiveness. Today, we see a dominance of the RbV in strategic management (Duschek, 2004). Although being inherently firm-centric, it contributes a key rationale for inter-organisational co-operation in R&D.

Basic Assumptions and Point of Departure

Inspired by the work of Edith Penrose (1959) and Alfred Chandler (1990, 1977, 1962) among others, key proponents of the Resource based View depict a firm as a 'collection of productive resources', which are integrated within an 'administrative organisation' (Penrose, 1995, p. 31) that links and co-ordinates resources and activities of individuals and groups.[5] These resources are heterogeneously distributed across firms. They are idiosyncratic, cumulative and tend to persist over time, leading to variety in firms. Hence, a central notion of the RbV is that firms *differ* in their resource endowments. It is this heterogeneity in resources which constitutes an important source of differential firm success.

Wernerfelt (1984), who also coined the term 'Resource-based View', defines resources as 'anything which could be thought of as a strength or weakness of a given firm. [Any] (tangible or intangible) assets which are tied semipermanently to the firm' (p. 172). However, assets which are mobile and commonly accessible will not provide unique competitive advantages. Hence, Barney (1991) identified central resource characteristics that contribute to sustained heterogeneity and differential firm success. These 'strategic resources' are *valuable* in that they significantly increase the efficiency and effectiveness of the firm. Second, they are *rare*, i.e., they are not available in abundance to any organisation. Third, they are *non-substitutable*, which excludes the possibility that any other resource or resource combination yields comparable results. Fourth, strategic resources are *imperfectly imitable*; i.e., competitors have no chance to easily and timely imitate them. The latter resource barrier is ascribed to cumulativeness, path dependency, 'causal ambiguity' and 'social complexity' of resources and their combination (Barney & Clark, 2007; Reed & DeFillippi, 1990). Cumulativeness and path dependency acknowledge the role of the unique historical circumstances that shaped the firm's development and characteristics. Causal ambiguity of resources implies a lack of understanding the causal link between the resources deployed by a firm and their outcome (Barney & Clark, 2007; Reed & DeFillippi, 1990). Social complexity is linked to the latter and implies that resources are collective goods. They are embedded in social relations, created and sustained in social interaction, as well as a firm's culture (Barney & Clark, 2007).

[5] Central proponents of this view are Peteraf (1993), Barney (1991), Dierickx and Cool (1989), Rumelt (1984), Wernerfelt (1984), as well as German representatives such as zu Knyphausen-Aufseß (1997; 1993), Rasche (2004) or Rasche and Wolfrum (1993).

These conditions are mainly found in the firm's intangible resources, particularly the individual and collective knowledge of its employees, their capabilities and competences. These ideas have been seized by researchers within the 'knowledge-based view' (Grant & Baden-Fuller, 2004, 1995; Grant, 1996; Spender, 1996) and the 'capability' or 'competence based view' of the firm (Hoopes & Madsen, 2008; Winter, 2000; Leonard-Barton, 1995; Kogut & Zander, 1992; Prahalad & Hamel, 1990). While the first underscores knowledge as key organisational resource and perceives the organisational advantage as residing in the organisational capacities to integrate, share and create (specialised bodies of) knowledge, the latter focuses on idiosyncratic skills or patterns of behaviour, particularly routines[6]. The key organisational endeavor is thus not only seen in the effective and efficient administration of resources, but also in the co-ordination and integration of knowledge and skills, including the generation of shared bodies of knowledge and common codes for knowledge sharing.

It is further stressed that static, unchanged resources and capabilities eventually deteriorate due to external environmental changes and technological discontinuities. In this sense, former strategic resources or 'core capabilities' can convert into 'core rigidities', putting the future competitiveness of the firm at risk (Leonard-Barton, 1995, 1992). Continuous and learning is perceived as necessary in order to adjust and enhance the knowledge and capability base and to substantiate the firm's enduring competitive advantage. Thus, firms constantly need to adjust and renew their knowledge and capabilities in order to remain competitive. These 'dynamic capabilities'[7] (Winter, 2003; Eisenhardt & Martin, 2000; Teece et al., 1997) or 'meta capabilities' (Miles et al., 2005, pp. 33 ff.) translate into a central rationale for co-operation from a Resource based View.

RbV and Co-operation in R&D

A firm's accumulated resources and capabilities delineate its boundaries and shape the pace and path of its development. Thus, based on the fundamental assump-

[6] A routine is defined as a 'repetitive pattern of activity in an entire organization, to an individual skill, or, as an adjective, to the smooth uneventful effectiveness of such an organizational or individual performance' (Nelson & Winter, 1982, p. 97).

[7] According to Teece et al. (1997), 'dynamic capabilities' serve to 'integrate, build, and reconfigure internal and external competencies to address rapidly changing environments' (p. 516). They strongly build on learning mechanisms and are particularly important in dynamic markets characterised by rapid, unpredictable change.

tion of heterogeneity in resource and capability endowments of organisations and the need to constantly renew them, the approach provides a key rationale for inter-organisational co-operation (e.g., Barney & Clark, 2007; Child et al., 2005; Das & Teng, 2000; Dyer & Singh, 1998; Eisenhardt & Schoonhoven, 1996).

Richardson (1972) was first to highlight the need to access complementary resources as a driver for inter-organisational co-operation. He stressed that organisations need to specialise around a set of capabilities that are rather similar. However, 'the organisation of industry has also to adapt itself to the fact that activities may be *complementary*' (p. 889, italics in the original). Inter-organisational co-operation then 'exist[s] because of the need to co-ordinate closely complementary but dissimilar activities. This co-ordination cannot be left entirely to direction within firms because the activities are dissimilar, and cannot be left to market forces in that it requires ... the matching, both quantitatively and qualitatively, of individual enterprise plans.' (pp. 889-890, 892). In this early contribution, Richardson outlines the basic rationale for inter-organisational co-operation from a resource or capability perspective: the need to access and closely combine complementary resources and capabilities which are too dissimilar to be provided internally.

Only considerable time later, the RbV has been explicitly and systematically extended to explain inter-organisational co-operation. Eisenhardt and Schoonhoven (1996) formulated a 'Resource based view to alliance formation' in which they stress strategic resource needs as important rationales for inter-organisational co-operation: 'strategic alliances arise when firms in vulnerable strategic positions need the resources that alliances bring' (p. 137). In the following, Das and Teng (2000) published a 'Resource-Based Theory of Strategic Alliances'. For them, 'the Resource based view considers strategic alliances and mergers or acquisitions as strategies used to access other firms' resources, for the purpose of garnering otherwise unavailable competitive advantages and values to the firm' (p. 36).

Considering the nature of strategic resources – value, rarity, non-substitutability and inimitability – it is implicit in the basic assumptions of the RbV that neither anonymous market transactions nor timely internalisation are feasible options for firms to leverage these resources (Das & Teng, 2000; Tallman, 2000). Especially tacit knowledge, capabilities and skills cannot be anonymously traded or easily and timely imitated (Grant & Baden-Fuller, 2004, 1995).[8] They need more extended and close relationships between the actors as compared to market transactions (Lane & Lubatkin, 1998). Thus, certain resources or capabilities can only be leveraged through more intimate working relationships with the resource or capability holder; i.e., through inter-organisational co-operation or merger and acquisition (M&A).

However, the alternative of merger or acquisition is often rejected due to (1) a fear of destroying central resources of the partner (e.g., because of an observed tendency that key knowledge holders tend to leave after merger or acquisition); (2) the acquisition of redundant or unnecessary resources which put an extra burden on the firm and limit its flexibility and (3) a lack of slack resources to outright purchase or merge with another organisation (Schoenmakers & Duysters, 2006; Das & Teng, 2000; Pisano, 1991). Moreover, the transient nature of a project opposes M&A as an alternative to co-operation. 'Thus, the distinct advantage of strategic alliances [or inter-organisational co-operation more generally, comment by the author] is to have access to precisely those resources that are needed, with minimum superfluity' (Das & Teng, 2000, p. 37).

Furthermore, the value of inter-organisational co-operation has been acknowledged to dynamically adjust the firm's resource base, increase its innovativeness and thus secure the firm's competitiveness (Schoenmakers & Duysters, 2006; Miles et al., 2005; Eisenhardt & Martin, 2000; Teece et al., 1997; Leonard-Barton, 1995, 1992). Leonard-Barton (1995) observes that 'very few, if any, companies can build core capabilities without importing some knowledge from beyond their boundaries' (p. 135). She stresses that especially in processes of product and process development, sole reference to existing internal resources and capabilities can prove dysfunctional (Leonard-Barton, 1992). With increasing differentiation and specialisation of knowledge and expertise and parallel a growing need to integrate multiple disciplines, technologies and capabilities, the knowledge and skills needed to affect R&D are increasingly distributed among organisations (Coombs & Georghiou, 2002; Coombs & Metcalfe, 1998). In particular, the combination of different resources that are distributed across organisations seems a lever for learning and novelty generation (Lam, 2005).

[8] In this vein, Tallman (2000) denotes that strategic resources and capabilities 'are difficult to identify and exchange because they are distributed throughout and embedded in the organisation itself' (p. 98). In regard to internalisation, Hamel (1991) states that 'for some skills, what Itami (1987) terms "invisible assets", the costs of internal development may be almost infinite' (p. 99).

Contributions, Limitations and Possible Extensions

The RbV has been well receipted within management and organisational sciences, providing a sound framework to explain enduring differences in the resource endowments and performance levels of firms. It has also become a major framework of reference to explain inter-organisational co-operation.

With an increasing breadth and diversity of knowledge and capabilities which are needed to effect invention and innovation, the mastery of which can hardly be provided by one organisation alone, inter-organisational co-operation is an effective means to integrate various differentiated resources. Thus, the RbV contributes important insights on inter-organisational co-operation in R&D, particularly learning and novelty creation in projects. By stressing resource and capability differences, it paves the way for an analysis of invention and innovation that is supposed to take place at the intersection of differentiated bodies of knowledge, capabilities and skills. However, while constituting important resource imitation barriers, the characteristics of key or strategic resources at the same time define the main challenges of inter-organisational co-operation: the combination of resources which are tacit, socially complex and causally ambiguous across organisations.

Compared to TCE, the RbV stresses content, value and effectiveness instead of governance efficiency and costs (Child et al., 2005; Eisenhardt & Schoonhoven, 1996). Furthermore, it considers that actors are not completely free in their choice of governance modes as resources are unevenly distributed across organisations and cannot be timely internalised. Hence, the choice between different governance forms is limited. However, by focusing solely on the value of a transaction, its costs and particularly the risks inherent in inter-organisational co-operation are not addressed.[9] Hence, a synthesis of both perspectives, TCE and RbV, is reasonable.

Moreover, the RbV is inherently firm-centric; i.e., key strategic resources reside within the firm. Thus, in line with the increasing network ecology of markets, it has been expanded by the so-called 'relational view' (Dyer & Singh, 1998). In their contribution, Dyer and Singh underscore that 'a firm's critical resources may span firm boundaries and may be embedded in interfirm routines and processes' (p. 661).

[9] Referring to the high failure rates of inter-organisational co-operation, Tallman critically notes that it 'seems that the costs of managing alliances must be higher than typically anticipated, the benefits less than expected, or both' (Tallman, 2000, p. 96).

Thus, differential rents may not only reside within an organisation but be found in jointly held resources. These jointly held resources can offer the same imitation barriers such as social complexity and causal ambiguity. However, no single firm could generate and appropriate these rents alone. Similarly, Gulati et al. (2000) stress the value of the co-operative tie itself which can be 'an inimitable resource by itself' (p. 207). As the locus of invention and innovation is nowadays frequently found in inter-organisational co-operation and networks, this extension seems valuable in its contribution to explain inter-organisational co-operation in R&D (Dyer & Singh, 1998; Gulati & Gargiulo, 1999).[10]

Before these ideas are expounded in the Social Network Perspective, a newer variant of the RbV, called 'Cognitive Theory of the Firm' is briefly introduced.

Excursus: A 'Cognitive Theory of the Firm'

Drawing on Penrosian ideas, but enriching and extending them with socio-psychological insights on cognition, learning and innovation, Bart Nooteboom (2009) recently formulated a 'Cognitive Theory of the Firm' which serves particularly well to remedy some of the insufficiencies of the RbV in regard to learning and novelty generation.

Basic Assumptions and Point of Departure

Synthesising his prior work on cognition, co-operation and the firm[11], Nooteboom published in 2009 a book called 'a Cognitive Theory of the Firm', where he draws on and connects elements from economic theory – particularly innovation theory,

[10] This has also been stressed by Penrose in a later edition of her seminal book where she acknowledges that alliance and network structures have gained in importance as an alternative mechanism leading to an ever increased fuzzyness of the boundaries of the linked firms (Penrose, 1995). 'The rapid and intricate evolution of modern technology often makes it necessary for firms in related areas around the world to be closely in touch with developments in the research and innovations of firms in many centres' (p. xix). She claims that this proliferation of networks might even call for a 'new theory of the firm' (p. xx).

[11] Some of his prior articles that relate to his current book are e.g., Nooteboom (2006a,b, 2004b, 1999).

TCE and the RbV –, cognitive science, sociology and social psychology. Nooteboom's goal is to develop a 'social cognitive theory of firms and organisations more generally and of organisation between organisations, with a focus on learning and innovation' (p. ix).

He departs from a constructivist, interactionist view of cognition: People perceive the world around them in accordance to the life paths they went through. Although cognition is highly personal, employment takes up large parts of an individual's environment and hence, firms have a strong influence on an individual's cognition, which leads to an alignment of cognition among individuals within a firm.

This is precisely what Nooteboom regards as constitutive for a firm: a firm serves as a 'cognitive focusing device' (pp. 72, 75 ff.). This collective cognitive focus has two purposes: on the competence side, it is needed to enable people to understand each other and connect and integrate complementary knowledge. On the governance side, focus is needed to motivate people to collaborate, share and connect knowledge. With the competitive advantage of a firm centering on knowledge and innovation, Nooteboom argues that new forms of internal governance – next to contracts, direction and hierarchy – need to be devised in order to secure the atmosphere for learning and innovation. In this sense, a cognitive focus provides an alternative governance instrument to align cognition and behaviour toward a common goal. Thus, a firm necessarily reduces cognitive variety to a certain extent in order to enable internal cohesion and co-ordination of knowledge and activities. This simultaneously implies a limitation of its range of activities, in terms of products, markets, technologies, assets, as well as of individual or organisational capabilities.

Nooteboom further distinguishes between surface regulations, manifest in organisational routines, which shape activities, their co-ordination and integration, and deep-level cognitive structures, which define an organistion's elementary self-perception, its underlying basic logics, principles, convictions and cognitive categories. Surface-level regulations can be interpreted as the phenotype of the organisation, whereas the deep-level cognitive structures correspond to its genotype, which guides cognition beyond rules and routines. These deep-level cognitive structures provide consensus and coherence in basic values which can be manifest in different bundles of surface regulation. For Nooteboom, organisations serve to co-ordinate on the deep level, providing the advantage of easier and timely understanding and agreement; which comes however at the expense of cognitive variety (pp. 81 ff.).

Cognitive Focus and Inter-Organisational Co-operation in R&D

While cognitive focus is needed for reasons of internal cohesion and mutual understanding, it leads to a lack of variety. Consequently, cognitive focus can result in myopia or lock-in. Hence, at times, external sources of cognition – ‘external economies of cognitive scope’ (Nooteboom, 2009, p. 131) – need to be mobilised to re-calibrate the organisational trajectory. Furthermore, exploration for novelty creation generally demands for more cognitive variety than a firm can provide internally. Through inter-organisational co-operation, internal focus can be conserved and, simultaneously, room for experimention and exploration is created. In Nooteboom’s words: ‘At some point it becomes better not to bring further and more diverging capabilities under a single focus, and to take the alternative of employing inter-firm collaboration, yielding a wider range of potential capabilities that may yield interesting combinations, and the preservation of more variety in each of them, and to engage in the more ad hoc, time consuming surface regulations for combination when and where the need arises’ (p. 119). Thus, inter-organisational co-operation is conducive to innovation, as it provides the ‘requisite variety’ (Van de Ven, 1986, p. 600) necessary to generate novelty in the Schumpeterian tradition, which Nooteboom adheres to. However, lacking shared deep-level structures and thus being dependent on surface regulations, the co-ordination and integration of knowledge between organistions is thought to be more difficult, necessitating conscious investments.

Furthermore, if firms are limited in their cognitive focus, how far can they be expected to reach out to varied cognition? As an answer to this question, Nooteboom (2009) introduces the notion of cognitive distance between organisations, defined as differences in their ‘perception, interpretation, value judgments, morality, emotions and feelings’ (p. 1). He suggests an inverted U-shaped function of the cognitive distance between organisations and novelty creation; expecting first increasing and then diminishing returns from cognitive distance. Thus, firms stick to a limited cognitive radius, in order to leverage external cognition.

Contributions, Limitations and Possible Extensions

Nooteboom synthesises basic ideas from RbV, TCE as well as innovation theory and combines them with insights from cognitive science, sociology and social psychology, as well as evolutionary theory. His ideas tie in with a recent upsurge of cognitively oriented approaches explaining organisational learning and path-dependency in an environment marked by constant change (Sydow et al., 2009; Lam, 2005; Nelson & Winter, 1982). As a response, organisations are perceived to develop mental representations to filter and interpret information, which helps them to make sense of the world and make decisions, but which can also lead to bias and lock-in (Lam, 2005; Nelson & Winter, 1982; March & Simon, 1958).

His idea of firms providing a strong cognitive focus offers a valuable alternative perspective on organisations in general and a rationale for inter-organisational co-operation in particular. However, the need for a widening of cognitive scope through inter-organisational co-operation does not substitute other rationales but complements them. As such, it provides an additional rationale for inter-organisational co-operation. This has also been acknowledged by Nooteboom: 'Organizational focus creates organisational myopia ... and in addition to all the other motives for inter-firm alliances, ... this gives an additional, cognitive reason, to prevent myopia by means of complementary outside cognition from alliance partners' (p. 223). For a comprehensive understanding of inter-organisational co-operation, the theory needs to be seen as a complement to the prior ones.

Nooteboom suggests that firms are constrained in their cognition and move within a limited cognitive scope. However, the notion of limited variety within organisations opposes concurrent aspirations for variety in views and perceptions within firms (Gherardi & Nicolini, 2002). While some cognitive focus is probably necessary to align interests and perceptions, there will also be variety within firms, particularly in large, diversified multinational companies. Thus, it might be suggested that a stronger cognitive focus and need for external cognitive variety might be found in small firms that focus on a particular niche.

Moreover, the theory is again rather firm-centric. While external impetus or variety are perceived as central reasons for inter-organisational co-operation, the locus of learning and innovation still resides within the focal firm.

In turn, while Nooteboom presents an additional rationale for inter-organisational co-operation, i.e., the need for external cognition, he also formulates its key challenges: The combination of not only different bodies of tacit, causally ambiguous and socially complex knowledge, but even more the integration of different mental models, cultural values and social identities.[12]

2.4 Social Network Perspective

Since the early 1990s – together with the upsurge of knowledge-based industries – the study of social networks in organisational science has spread widely and has permeated into different areas, particularly into co-operation, innovation and internationalisation research (Borgatti et al., 2009; Johanson & Vahlne, 2009; Powell & Grodal, 2005; Verspagen & Duysters, 2004; Gulati et al., 2000; Gulati, 1998; Powell & Smith-Doerr, 1994).[13] In particular, network studies are currently topically engaged in explaining the sources for superior organisational learning and novelty generation (Saviotti & Catherine, 2008). In these studies, not only the bilateral tie, but the network is perceived as the 'locus of innovation' (Powell & Brantley, 1992, p. 370) as well as the central unit of investigation.

Basic Assumptions and Point of Departure

Proponents of a Social Network Perspective (SNP) draw on insights from social sciences and network analysis to explain organisational behaviour in general as well as antecedents, structures and outcomes of inter-organisational co-operation in particular. According to Nohria (1992, pp. 4-7), studying organisations from a network perspective implies the acceptance of five basic premises:

[12] Tajfel (1982a) defines social identity as 'that *part* of the individuals' self-concept which derives from their knowledge of their membership of a social group (or groups) together with the value and emotional significance attached to that membership' (p. 2, italics in the original).

[13] Networks are currently discussed as important catalysts for international operations, among them international co-operation, particularly for small firms (e.g., Johanson & Vahlne, 2009; Coviello, 2006; Coviello & Munro, 1997).

1. All organisations are in important respects social networks and need to be addressed and analysed as such;
2. An organisation's environment is properly seen as a network of other organisations;
3. The actions (attitudes and behaviours) of actors in organisations can best be explained in terms of their position in networks of relations;
4. Networks constrain actions, and in turn are shaped by them;
5. The comparative analysis of organisations must take into account their network characteristics.

Most authors follow Laumann et al. (1978) who define social networks as 'a set of nodes (e.g., persons, organisations) linked by a set of social relationships (e.g., friendship, transfer of funds, overlapping membership) of a specified type' (p. 458, taken from Gulati, 1998, p. 295). According to this definition, different types of actors (nodes) can be involved and considered at different levels of aggregation, from individuals to groups or organisations. Furthermore, network relationships can differ in content and type from formal and evident ties (e.g., accompanied by resource streams) to ties which are rather informal and hidden to outside observers (e.g., of a more affective nature such as friendship) (Hite, 2008; Nohria, 1992). Furthermore, relationships can be uni- or multiplex, which means that they can be based on a single type or they can comprise multiple, overlapping types of ties.

From a social network perspective, the concept of 'embeddedness' becomes central, implying 'the fact that exchanges typically have a history, and that this history results in the routinisation and stabilization of linkages among members. As elements of ongoing social structures, actors do not respond solely to individualistically determined interests ... a structure of relations affects the actions taken by the individual actors composing it. It does so by constraining the set of actions available to the individual actors and by changing the dispositions of those actors toward the actions they may take.' (Marsden, 1981, p. 1210, taken from Gulati 1998, p. 295). It is centrally acknowledged that organisational behaviour does not only follow pure economic rationality but is also motivated and justified by social rationales and history (Granovetter, 1992, 1985).[14] Thus, relational ties and the resultant social

[14] Offering an alternative view on the character of firms, industrial dynamics and structures, a social network perspective pays tribute to Granovetter's (1992, 1985) critique of an often under-socialised depiction of economic processes. Building on these premises, proponents of SNP argue in favour of considering economic action as social interaction embedded in social

networks are suggested to have a strong impact on organisational as well as individual actions and performance. They convey advantages, e.g., access to resources and information, but they also constrain behaviour, e.g., by inducing certain norms of behaviour or by limiting the awareness sets of actors.

In particular, proponents of a SNP discuss two different kinds of advantages which accrue from the network and an actor's position within it: 'relational advantages' emanating from different kinds of direct and indirect relationships and 'structural advantages' which result from preferential positions within networks (Gulati, 1998). Coleman (1990, 1988), for example, points out relational advantages which he attributes to dense social networks. According to him, dense networks convey benefits, which are commonly summarised as 'social capital'. Social capital is defined as 'the sum of the resources, actual or virtual, that accrue to an individual or group by virtue of possessing a durable network of more or less institutionalized relationships of mutual acquaintance and recognition' (Burt, 2001, p. 2, referencing Bourdieu and Wacquant, 1992, p. 119). Specifically, social capital conveys stability and trust which inhibits opportunistic behaviour.

Granovetter (1983, 1973) by contrast critically discusses individual tie strength. He distinguishes between 'weak ties' and 'strong ties' in regard to the frequency of contact between actors. In an analysis on job finding and the role social ties played within this process, he asserts the preferential position of those applicants that are connected to many weak ties as these convey access to (heterogeneous) information that is unavailable to others (Granovetter, 1973).

Similarly, Burt (2008, 2001, 1992a,b) argues against too dense and redundant ties, and turns to the overall structure of networks (positional advantages). He argues that by spanning 'structural holes' (Burt, 1992b, p. 56), i.e., by bridging otherwise unconnected network nodes, actors can profit from direct access to non-redundant information and resources not available to others. Moreover, they can play off their positional advantage in brokerage roles whereby they can channel and influence information forwarded to other, less advantageously positioned actors and thus exert control over resources and information.

networks. Granovetter (1985) writes that 'actors do not behave or decide as atoms outside a social context, nor do they adhere slavishly to a script written for them by the particular intersection of social categories that they happen to occupy. Their attempts at purposive action are instead embedded in concrete, ongoing systems of social relations' (p. 487).

All in all, there are rivaling benefits and liabilities from different relational characteristics and network positions. Coleman (1990) partially reconciles these by suggesting that ‘a given form of social capital that is valuable in facilitating certain actions may be useless or even harmful for others’ (p. 302).[15]

SNP and Inter-Organisational Co-operation in R&D

Basically, advocates of a Social Network Perspective within organisational studies argue that co-operation research needs to go beyond considering co-operative ventures as dyadic, or bilateral, relations and extend the analysis to the overall structure of ties, their characteristics and multi-dimensionality (Hite, 2008; Gulati et al., 2000; Gulati & Gargiulo, 1999; Gulati, 1998). Otherwise, a distorted picture is eventually drawn. Accordingly, Hite (2008) claims that ‘explanations of strategic networks at the dyadic level, however, require understanding the systemic and multidimensional nature of network ties’ (p. 134). According to Gulati (1998), adopting a Social Network Perspective can be informative throughout all the stages of a co-operation project: its formation, the choice of governance structure, its dynamic evolution, performance as well as the performance consequences for those involved.

The endorsement of ideas from a SNP has mainly two kinds of implications for understanding inter-organisational co-operation:

- Structural implications: Economic action has strong social constituents; it is shaped by social structures, relationships and individual positions in networks.

- Normative implications: Strategic actions can be initiated specifically with the goal to respond to and influence network structures. They are simultaneously constrained by normative rules of behaviour and social sanctioning mechanisms.

Regarding the **structural implications**, it is assumed that key precursors, actions and outcomes associated with inter-organisational co-operation are strongly shaped by social ties and networks, where different types of ties exist and intervene

[15] Similarly, Gilsing & Duysters (2008) conclude that ‘the question is not who is right, but who is right under what conditions’ (p. 694). This trade-off is central in the discussion of relational distance in section 4.4.6.

(Gulati, 1998). On the one hand, networks serve as conduits through which resources and information are exchanged. They act as ‘prisms’ (Podolny, 2001, p. 35) through which reputation and legitimacy are signaled, the quality of information and resources are reflected and trusted relationships supported through expectations of norm conformative behaviour (Podolny, 2001; Rowley & Baum, 2008; Ahuja, 2000; Gulati & Gargiulo, 1999). Powell (1998) holds that ‘a firm’s portfolio of collaborations is both a resource and a signal to markets, as well as to other potential partners, of the quality of the firm’s activities and products’ (p. 231). The trust which networks can convey can be important enablers of interactive learning and innovation. On the other hand, networks can also constrain individual action, leading to ‘bounded agency’ as organisations might be locked into certain relationships, be denied access to others or lack information about certain possibilities and alternatives which escape the network horizon (Hite 2008; Powell 1998). These examples illustrate the ambivalent role of social networks: They open up opportunities and simultaneously restrain others. Thus, they strongly influence an agent’s behaviour.

Besides, a Social Network Perspective also forwards **normative implications** for organisations (Nohria, 1992).[16] These normative implications pertain to two levels: the structural or positional level, and the level of the individual tie. First, due to the importance attached to networks for firm performance, learning and novelty generation, it is expected that firms actively and consciously seek to lever social relationships and to invest in changes in the overall network structure to improve their position. Thus, network structures can act as ‘strategic catalysts’ (Hite, 2008, p. 148) which motivate actors to invest in changes in the network. Hite (2008) suggests that ‘network ties, as continuously changing multi-dimensional systems, can be strategic to the extent that network actors intentionally design and manage them to facilitate firm performance’ (p. 136). Similarly, Gulati (1998) asserts that firms can ‘visualize the desired network structure of alliances in the future and work backwards to define their current alliance strategy’ (p. 297). Thus, network ‘engineering’, (Gulati et al., 2000, p. 208) is a valuable strategy. Awareness of the structural advantages networks offer and about their current structure should propel organisations to actively seek or leverage these advantages (Rowley & Baum, 2008). Yet, the degree to which network structures and positions are the outcome of actors actively and deliberately seeking certain network positions, or whether

[16] Nohria (1992) assumes that ‘the term “network” is used to describe the observed pattern of organisation. But just as often it is used normatively: to advocate what organizations must become if they are to be competitive in today’s business environment’ (p. 1).

these positions are a by-product of other considerations (e.g., resource needs) and determined by structural properties themselves is part of a controversial discussion (Borgatti et al., 2009; Rowley & Baum, 2008; Burt, 2001; Nohria, 1992). Supporting the first view, a number of researchers suggest that actors are aware of network structures and their positions within them and can act upon them (e.g. Rowley & Baum, 2008; Hite, 2008; Gulati et al., 2000; Burt, 1992b; Granovetter, 1992; Nohria, 1992; White, 1992). Second, it is expected that network considerations also affect the organisation's behaviour within a bilateral partnership. As a firm's behaviour within a relationship emits on its broader network standing and with the expectation of social sanctioning mechanisms, it is likely to resort to a trusted, voice or loyalty rather than exit, strategy within the co-operation (Gulati, 1995b).

Contributions, Limitations and Possible Extensions

A Social Network Perspective joins insights from social theory and network analysis to elucidate organisational behaviour. Its key benefit is a broadening of the perspective to integrate social structures, aspirations, as well as history into the analysis of organisational behaviour. Social factors such as trust, personal attachment or social identity as well as social constraints become central determinants of economic action. In particular, proponents of a Social Network Perspective discuss networks as conduits of resources, as channels of information or as prisms of quality, but also as locations of social control and behavioural conformity. As such, SNP builds on previous insights from RbV and TCE, but complements and extends these. Presumably, a neglect of social and network structures yields a biased picture of inter-organisational co-operation, its antecedents, actions and outcomes.

However, while positing to strive a balance between under- and over-socialised research, current proponents tend to adopt an 'over-socialised' view to economic activity, dismissing management action, or at least explaining it as bounded to social structures. This becomes particularly evident in the discussion about how much agency remains in entering relationships or purposefully engineering network structures (e.g., Borgatti et al., 2009; Rowley & Baum, 2008; Burt, 2001; Nohria, 1992).

Moreover, despite its claim to explain interactive learning and novelty generation, current research largely remains descriptive. It concentrates on the study of network structures and the benefits accruing to actors who display specific relational and positional advantages (Gilsing & Duysters, 2008; Beckert, 2005; Sydow & Windeler, 1998; Nohria, 1992). Other factors as well as tie content largely remain a 'black box' (Gilsing & Duysters, 2008, p. 694; Hite, 2008, p. 134). The need for a deeper exploration of ties, their content and potential is claimed and is only recently starting to be incorporated into social network studies (e.g., Cowan & Jonard, 2008).

2.5 Summary

Concurrently, there is no single, holistic theory to explain inter-organisational co-operation, but a number of different lines co-exist. Based on an evaluation of their contribution to elucidate interactive learning and novelty generation in inter-organisational projects, three lines of theory have been identified as central: Transaction Cost Economics (TCE), the Resource Based View (RbV) with a 'Cognitive Theory of the Firm' as recent offspring and a Social Network Perspective (SNP).

TCE and RbV are currently recognised as connected building blocks of a general theory of the firm and thus also inter-organisational co-operation. TCE stresses relational risks emanating from bounded rationality and opportunistic behaviour in market transactions. These lead to additional costs of using markets, so-called transaction costs. Through the choice of different governance forms – from markets to hybrids and hierarchies – actors seek to minimise these costs. The governance forms adhere to different contract laws: classical contract law (markets), neoclassical contract law (hybrids) and employment contract law (hierarchies). Each of these exhibits distinct advantages in regard to the criteria adaptability, incentives and opportunities for control. Specifically, interactive learning and novelty generation in projects is characterised by high levels of uncertainty in regard to the course and outcome of the project as well as the partner's knowledge, his contribution and behaviour. Moreover, specific investments in learning are supposed to be incurred, while the project-character implies a limited overall duration of the interaction. In this situation, hybrid governance forms under neoclassical contracts offer central benefits. They allow for flexible, individual and concerted adaptations, retain incentives and at the same time offer some mechanisms of control. However, they are also characterised by behavioural leeway which can destabilise the relationship and support opportunistic behaviour.

The RbV underscores the role of heterogeneously distributed resources for competitive success and suggests inter-organisational co-operation as a way to gain (timely) access to strategic resources which are not controlled by the firm and to constantly develop and renew the firm's competitiveness. In particular, strategic resource characteristics – rarity, inimitability and non-substitutability – inhibit their timely internalisation. These characteristics are often found in a firm's accumulated knowledge as well as its capabilities and skills. Access to these resources demands more intense interaction among the organisations than market relationships offer. At the same time, these resource characteristics express key challenges in inter-organisational co-operation, particularly in the deliberate sharing of tacit, contextual, ambiguous and socially complex knowledge and capabilities.

One recent offspring of the RbV is the 'Cognitive Theory of the Firm' developed by Nooteboom (2009). For Nooteboom, firms need to create a cognitive focus in order to align interests and allow for communication and co-ordination within the organisation. However, in order to recalibrate its trajectory and allow the inflow of new ideas, external cognition through collaboration is needed in order to sustain competitive advantage and generate novelty. Again, the coupling of different organisational cognitive foci defines the benefits but also the challenges of inter-organisational co-operation for interactive learning and novelty generation.

While these views are rather firm-centric, scholars recently increasingly adopt a Social Network Perspective in organisational research. Proponents of this view argue in favour of a more socially instructed, network-based perspective on organisational behaviour, particularly in regard to inter-organisational co-operation. It is claimed that social factors and network relations as well as network positions strongly shape organisational behaviour which can explain antecedents, actions and outcomes of inter-organisational co-operation. For example, network relationships not only convey resources, information and trust; they also impose norm-conform behaviour on organisations. Moreover, firms might use these insights to consciously 'engineer' their relationships and networks.

Together, these theories provide a balanced and comprehensive view of the rationales, social constituents, benefits but also risks and challenges inherent in inter-organisational co-operation projects within R&D. They shape the perspective on inter-organisational co-operation adopted in this thesis.

3 Learning and Novelty Generation in Inter-Organisational Co-operation

3.1 Overview

In Chapters 1 and 2, it has been outlined that the key resource in inter-organisational co-operation in R&D is knowledge. Correspondingly, the central process within an inter-organistional co-operation project constitutes knowledge sharing. Thus, this chapter starts with an outline of the process of inter-organisational knowledge sharing and identifies key challenges within this process (section 3.2). Subsequently, it turns to the 'preparedness' of the partners, in terms of their ability and motivation, as key precondition for knowledge sharing (section 3.3). One such motivational factor is trust, which is assumed to play an important role in knowledge sharing, and which is addressed separately in section 3.4. Section 3.5 provides a summary of the main insights of this chapter.

3.2 Processes and Challenges of Knowledge Sharing

As has been outlined in section 1.4, research and development – as well as learning and novelty generation more broadly – centers primarily on knowledge. Similarly, following the argumentation of the Resource based View, the central rationale for inter-organisational co-operation in R&D is access to the partner's distinct bodies of (scientific) knowledge and (technical) capabilities. While knowledge is the central object, knowledge sharing is the key process in inter-organisational co-operation in R&D (Olsen, 2009).

Van den Hooff and Schipper (2009) define knowledge sharing as 'the process where individuals mutually exchange their (tacit and explicit) knowledge and jointly create new knowledge' (p. 3). In inter-organisational R&D directed toward interactive learning and novelty generation, this tends to be an iterative, recursive process of knowledge sharing, absorption, creation and integration across organisational

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boundaries, which is best described in the model of knowledge sharing and knowledge creation by Nonaka and Takeuchi (1995, pp. 62 ff.).[1]

According to this model, knowledge can either be shared through processes of 'socialisation' where tacit bodies of knowledge are directly shared or 'externalisation' where tacit knowledge is first expressed and then shared. Socialisation thus depends on face-to-face contact where knowledge is shared and build through observation, imitation and practice. Nonaka and Takeuchi (1995) stress 'shared experience' (p. 63) as key to acquiring tacit knowledge directly from the source. Externalisation by contrast implies the expression or formulation of tacit knowledge orally or in written form, often with the help of analogies or artifacts. This shared knowledge is then 'recombined', 'internalised' and put to new uses, which eventually spurs another loop of knowledge sharing along the lines of socialisation and externalisation. Thus, between organisations knowledge is either shared directly through face-to-face contact or indirectly through the intermediary step of externalisation (Witt et al., 2007). In regard to transnational R&D projects within multinational firms, Boutellier et al. (2000) conclude that 'in order to carry out interlocal R&D projects, externalization and socialization need the most management attention' (p. 212).

While knowledge sharing is already a challenging process within organisations, the difficulties are typically augmented when two distinct organisations engage in knowledge sharing (Child et al., 2005).

First, the sharing of knowledge is not straightforward which follows from current epistemological insights on knowledge, its generation and characteristics (see section 1.4). It has been outlined in section 2.3 that the most valuable knowledge tends to be characterised by tacitness, causal ambiguity and social complexity.[2] It is assumed that great parts of tacit knowledge have slipped an organisations, respectively an individual's, 'focal awareness', but faded into 'subsidiary awareness' (Nelson & Winter, 1982, p. 78, referencing Polanyi 1966). This corresponds to the current view of knowledge, or 'knowing' (Amin & Cohendet, 2004, p. xiv), as a practice or process, embrained or embodied in organisational routines or individual skills, rather than perceiving knowledge as a stock which is possessed at any point in time (Nonaka

[1] For a more recent treatise of the so-called SECI (**S**ocialisation, **E**xternalisation, **C**ombination, **I**nternalisation) model by one of the authors, see also Nonaka et al. (2008).

[2] Similarly, Johnson et al. (2002) assume that 'one of the most important reasons for industrial networks is the need for firms to enable to share and combine elements of *know-how*' (p. 251, italics added by the author).

et al., 2008; Amin & Cohendet, 2004; Nelson & Winter, 1982).[3] This unconsciousness of key constituents of knowledge, capabilities or a skill and its process character renders knowledge sharing particularly tricky.[4] Nelson and Winter (1982) identify three limits to the articulation of tacit knowledge (pp. 80 ff.):

1. Limits imposed by the time rate of information transfer. Hence, the verbal description of process stages inherent in a skill is not simultaneous to the act of affecting the skill;

2. Limited causal depth of knowledge. This refers to the unconsciousness of many important elements that are rather embrained or embodied in the knowledge holder;

3. Lack of coherence, leading to a trade-off between explaining in detail and transferring the big picture.

Nooteboom (1999) assumes that knowledge tends to be particularly tacit in small firms. He provides two reasons for this assumption. First, small firms often operate in niche markets and base their expertise more on craft-like and hence tacit, procedural knowledge. Second, co-ordination in small firms is often more informal with less knowledge being readily codified in blueprints, written procedures, or explicit models compared to large firms. Accepting this argument, it can be assumed that inter-organisational knowledge sharing involving SMEs necessitates particular investments in socialisation or externalisation of knowledge.

Moreover, these limits to the articulation of knowledge might be particularly pronounced in the case of new knowledge where a generalised 'codebook' (Cowan et al., 2000, p. 225) does not yet exist. Thus, Amin and Cohendet (2004) add the following steps as prerequisites to externalisation: creating models, creating languages and creating messages (see also Cowan & Foray, 1997). In this case, socialisation

[3] Central to this is the notion of knowledge as residing within 'communities of practice' (Amin & Cohendet, 2004; Gherardi & Nicolini, 2002; Wenger, 1998; Brown & Duguid, 1991; Lave & Wenger, 1991). Lave and Wenger (1991) define a 'community of practice' as 'a system of relationships between people, activities, and the world; developing with time, and in relation to other tangential and overlapping communities of practice' (p. 98). They are perceived as locus of knowing and learning because of their mutual engagement, shared work, sense of joint enterprise and shared repertoire of communal resources (Wenger, 1998).

[4] Von Hippel (1994) refers to the problems faced in the transfer of knowledge or a practice from one place to another as knowledge 'stickiness'.

as a more direct form of knowledge sharing between individuals and organisations might be a more effective form of knowledge sharing than externalisation.

Second, it has been suggested that knowledge is created, accumulated and justified over time at the level of the individual, a group, such as a lab, a community, an organisation and even at a society or country level (Witt et al., 2007; Brown & Duguid, 1991; Knorr-Cetina, 1984). Thus, knowledge is subjective or collective, socially shaped, and its interpretation is dependent on its context (Nonaka et al., 2008; Lam, 2005; Bhagat et al., 2002; Davenport & Prusak, 1998; Nonaka & Konno, 1998; Cohen, 1986).[5] Bhagat et al. (2002) as well as Davenport and Prusak (1998) suggest that knowledge is derived from information by contextualising the information and comparing it with an existing standard and by examining its consequences in the light of one's own experiences, actions and aspirations. Thus, it is perceived that tacit and externalised or explicit knowledge are inseparably linked. The interpretation of externalised knowledge always intertwines with tacit knowledge (Nightingale, 1998). Even when expressed, the interpretation of information will vary.

Consequently, data transmitted between partners in inter-organisational co-operation is put into the context of the recipient; it is 'thus never engaged "as is", or, stand-alone, as it were; it is absorbed into a new context where it needs to "fit", that is, to be meaningful, connected and useful. Absorbed knowledge will be re-contextualized' (Brannen et al., 2007, p. 4). Hence, knowledge sharing entails re-construction of knowledge by the receiver, as well as deconstruction of knowledge into its perceived constituents by the sender (see the problems in externalisation of tacit knowledge as described above). Becker-Ritterspach (2006) calls this double de- and re-contextualisation 'dialectic transformation' (p. 364). This transformation can constitute a novel combination in the sense of Schumpeter (see section 1.4), a 'moment of creation' (Becker-Ritterspach, 2006, p. 364) by itself. However, it can also constitute a prime source of misunderstandings and friction in inter-organisational knowledge sharing.

[5] Extending their model of organisational knowledge creation, Nonaka and Konno (1998) argue that knowledge creation needs a shared context between those involved in the process. They introduce the Japanese word 'ba', literally 'place', as an important ingredient for advancing individual as well as collective knowledge. Ba is understood as a 'shared space for emerging relationships. This space can be physical (e.g., office space), virtual (e.g., e-mail, teleconference), mental (e.g., shared experience, ideas, ideals), or any combination of them' (p. 40). It provides a shared 'context, which harbours meaning' (p. 40).

It follows that both the benefits from re-contextualising information in inter-organisational co-operation as well as the difficulties experienced in knowledge sharing are relative and depend on the context the sender and the receiver of information share. Before these ideas are expounded in Chapter 4, two central concepts which are discussed in the literature on knowledge sharing as key determinants of the success of the process are introduced.

3.3 Ability and Motivation for Knowledge Sharing

Considering the difficulties in knowledge sharing just described, concurrent literature in knowledge management stresses two factors which centrally influence the process of knowledge sharing: the ability and the motivation of the partners (Easterby-Smith et al., 2008b; Minbaeva, 2008; Szulanski, 2006; Hinds & Pfeffer, 2003).

Ability implies a cognitive preparedness of the partners to share knowledge. Two further concepts are central, namely the '(relative) absorptive capacity' as well as the '(relative) disseminative capacity' of the partners (e.g., Mu et al., 2009; Easterby-Smith et al., 2008a; Minbaeva, 2008; Brannen et al., 2007; Minbaeva & Michailova, 2004; Martin & Salmon, 2003; Lane & Lubatkin, 1998; Cohen & Levinthal, 1990).

'Absorptive capacity' as a determinant of the ability to internalise external knowledge has gained widespread acceptance and use within the scientific literature. It is defined as the ability to recognise, assimilate and apply external knowledge (Cohen & Levinthal, 1990). In current contributions, absorptive capacity is mostly applied to explain knowledge assimilation on an abstract organisational level and the variables defined to determine an organisation's absorptive capacity tend to be aggregate measures, such as the overall R&D expenditure of an organisation or its network embeddedness (Easterby-Smith et al., 2008a). In regard to inter-organisational co-operation, Lane and Lubatkin (1998) have shifted the concept from the organisational to the dyadic level. Their narrower concept of 'relative absorptive capacity' describes the ability to absorb knowledge from a specific source. An organisation's capacity to uptake external knowledge is judged in relation to a particular partner, which is the central level of analysis in inter-organisational co-operation (Brannen et al., 2007; Martin & Salmon, 2003; Lane & Lubatkin, 1998).

However, absorptive capacity is a partial concept in inter-organisational co-operation as it solely concentrates on the recipient of knowledge. Considering the problems of externalising tacit, personal or collective knowledge (see section 3.2), effective and efficient knowledge sharing is not only dependent on the qualification of the recipient of information, but also on the source or sender of information; i.e., the knowledge holder (Mu et al., 2009; Minbaeva, 2008; Minbaeva & Michailova, 2004). His capacity to assess information needs, to decontextualise, externalise and communicate knowledge in a way appropriate for the respective receiver is of equal importance. 'Disseminative capacity' is hence understood as the ability to share knowledge with another in a way that it can be understood and put to use by the receiver.[6] Analogue to the relative conceptualisation of absorptive capacity, the notion 'relative disseminative capacity' is introduced here. Together, they characterise the partners' abilities to share knowledge effectively.

Motivation refers to the willingness and commitment[7] of an organisation and its members to share knowledge with and uptake knowledge from the partner (Hinds & Pfeffer, 2003). While the ability to disseminate or absorb knowledge refers to a state of cognitive preparedness, motivation comprises the emotional, calculative or conative preparedness; i.e. it introduces a more proactive element. It propels the organisation and its members to invest in knowledge sharing and integration. The motivation is closely related to the relational risks perceived for the organisation as well as for the individual. It includes rational as well as emotional components or feelings, which shape individual and also organisational behaviour. Five central factors have been identified from the literature which alone and together determine the motivation to share knowledge: social identity, empathy, trust, credibility and interest (Nooteboom, 2010, 2009; van den Hooff & Schipper, 2009; Johanson & Vahlne, 2009; Palmisano, 2008; Szulanski, 2006; Andrews & Delahaye, 2000).[8] Van den Hooff and Schipper (2009) call these important 'soft factors' (p. 2) for knowledge sharing. This activating element, again, needs to be present on the part of the sender as well as on the part of the recipient.

[6] While the problem of externalising tacit knowledge is topically addressed in studies on the economics of knowledge, it is much younger and has received less attention in studies on organisational knowledge sharing (Yamao & Fenwick, 2006).

[7] Under commitment, Johanson and Vahlne (2009) subsume a preparedness to invest in a relationship, a desire to continue the relationship and resilience implying that short-term benefits are sacrificed for long-term stability.

[8] Particularly trust is variously underscored as an important motivational factor to share knowledge. Due to its centrality it is treated separately in section 3.4.

If the ability and/or the motivation to share knowledge between the partners are low, friction in the process of knowledge sharing is likely to occur. These friction losses are well illustrated in the four potential 'pathologies' in information transfer summarised by Picot et al. (2003, p. 86, in reference to Scholl 1992):

1. generally producible information is not produced;
2. generally obtainable information is not obtained;
3. existing information is not or only distortedly transmitted, and
4. transmitted information is mal understood or not used.

Given the absence of either the ability, the motivation to share knowledge, or both, efficient and effective knowledge sharing are only to be realised at high costs. Moreover, ability and motivation are likely to be intertwined with ability shaping motivation and motivation in turn influencing investments in the ability to share and uptake knowledge.

3.4 The Role of Trust

Trust constitutes an important motivational factor for inter-organisational knowledge sharing. It is characterised by Nooteboom (1999) as 'the glue that keeps business partners together' (p. 24). Nooteboom (2009) also provides a definition of trust as 'accepting relational risk in the expectation that the trustee will not cause great harm, *even though he has both the opportunity and incentive to do so*' (p. 78, italics in the original).

Thus, the particular role of trust emanates from an element of risk generally present in inter-organisational co-operation and even more so in an inherently uncertain field such as R&D. In inter-organisational R&D, two kinds of risks can be distinguished: the risk of technical failure of the project, implying that the initial expectations don't materialise as well as the relational risk associated with the partner, his resources and capabilities as well as his intentions and behaviour. Specifically, relational risks comprise the risks that the shared knowledge is inappropriately used or exploited by the partner, that it leaks to outside sources through channels which are uncontrollable from the point of view of the firm or that time and money is wasted in an investment which is from the start unlikely to pay off as the partner lacks the ability and/or motivation to contribute, which is difficult to assess ex ante (see section 2.2). Thus, co-operation in R&D entails a degree of vulnerability of the partners (Möllering, 2006).

It is assumed that trust mediates this (perceived) vulnerability in situations where a firm lacks the ability to assess the resources, intentions and behaviour of the partner (Johanson & Vahlne, 2009; Möllering, 2006; Nooteboom, 2002). It is perceived to promote the building of joint expectations, increase commitment and to persuade people to share knowledge (Nooteboom, 2010; Johanson & Vahlne, 2009). Together, trust is seen as an important ingredient in knowledge sharing, learning and the development of new knowledge, particularly in uncertain situations (Nooteboom, 2010; Johanson & Vahlne, 2009; Nielsen, 2007; Nahapiet & Ghoshal, 1998; Madhok, 1995).

Commonly, authors distinguish between **objects of trust** and **foundations of trust** (e.g., Möllering, 2006; Nooteboom, 2002; Lane, 2000). Objects of trust can be found at different levels: individuals, organisations, systems and societies.[9] Next, focal objects of trust can be different characteristics, such as competences and behaviours. Trust in competence entails trust in the ability of an object, while trust in behaviour includes for instance integrity, honesty, benevolence and commitment to 'operate to the best of his competence' (Nooteboom, 2002, p. 9). Foundations of trust can be broadly divided into rational reasons and psychological causes (Nooteboom, 2002). Lane (2000), for example, divides the sources of trust into calculative trust, value- or norm-based trust and common cognition as bases for trust.[10] Calculative trust builds on a weighing of the cost and benefits of certain courses of action for both partners and thus a rational decision, which can comprise considerations about the damage of defection for future or third-party co-operation as well as legal

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[9] Note that these levels can be interlinked: for instance, trust in organisations can entail trust in its employees, whereas societies can shape trustworthy behaviour of its members (again, individuals and organisations).

[10] Different taxonomies of sources for trust are discussed in contemporary literature. Integrating these, Nooteboom (2002) identifies calculation-based, knowledge-based, cognition-based, affect-based and identification-based trust; although he admits great overlap within these dimensions. Other contributions which discuss different sources of trust are for example found in Nooteboom (2010), Nooteboom (2004b), Child et al. (2005), Currall and Inkpen (2002), Child (2000), Lane (2000) and McAllister (1995).

deterrence or enforcement of rights.[11] Value- or norm-based trust builds on common values and a shared concept of moral obligation, including aspects of mutual identification. Finally, trust based on common cognition supports the understanding of the other and renders his actions predictable. It often builds on previous relationship and knowledge of the other.

Taken together, trust in its various facets is supposed to strongly influence the motivation of the partners to contribute to the co-operation project which is in turn an important precondition for knowledge sharing. Particularly SMEs, which lack the capacity to endure long and costly law suits and which need to economise on scarce resources more generally, are concerned by relational risks. They might rely more heavily on network resources, both in the form of material as well as immaterial resources in the form of trust.

3.5 Summary

This chapter has explored the process of interactive learning and novelty generation. Assuming knowledge as key resource within inter-organisational co-operation, knowledge sharing has been identified as key process. It has been outlined that inter-organisational co-operation in R&D entails an iterative, recursive process of knowledge sharing, combination and integration between the partners. Following Nonaka and Takeuchi (1995), socialisation as a direct way to share tacit knowledge and externalisation as an indirect way to make tacit knowledge transparent are key processes.

Notwithstanding these possibilities, knowledge sharing is not a straightforward task as the most valuable or strategic knowledge is found within a firm's tacit, individual or collective, situated knowledge and skills. This knowledge is supposed to be highly specific, contextual and often faded to subsidiary awareness. Thus, it is prone to limits in externalisation. Correspondingly, contemporary contributions underscore the ability and the motivation of knowledge holder and addressee as key precondi-

[11] Note that there is a fallacy in the argument as trust commonly 'begins where rational prediction ends as trust bridges the information uncertainty' (Lane, 2000, p. 6). However, a rational consideration and prediction of the other's behaviour plays an important role in inter-organisational co-operation, increasing the confidence in the partner and thus affecting behaviour.

tions for knowledge sharing. The ability to share and uptake knowledge comprises the absorptive as well as the disseminative capacities of the partners. Motivation has been described as the driving force. Particularly trust has been identified as a central motivational component. Three types of trust have been introduced, namely calculative, value- or norm-based and cognition-based trust with respect to the competence and behaviour at the level of the individual, organisation, system or society. In a risky and uncertain process such as R&D, trust is thought to raise the commitment of the partners and to support knowledge sharing.

Moreover, both ability and motivation to share knowledge have been discussed as relative sizes which can only be assessed in relation to the particular partner. They are supposed to be centrally influenced by the amount of shared context of the partners; a suggestion which is expounded in-depth in Chapter 4.

4 Distant Relationships for Learning and Novelty Generation

4.1 Overview

Chapters 2 and 3 have served to introduce the key building blocks that underpin the theoretical argument on the impact of different forms of distance shaping interactive learning and novelty generation in inter-organisational projects. In Chapter 2, it has been outlined that inter-organisational co-operation is sought to access and combine different resources, primarily knowledge and skills, from different organisations in order to close resource gaps or to yield a requisite level of variety conducive to learning and novelty generation. Moreover, key risks and challenges emanating from inter-organisational co-operation, such as relational risks, as well as its social constituents have been discussed. Considering knowledge as key resource for inter-organisational co-operation in R&D and knowledge sharing as key process, Chapter 3 has expounded the challenges and prerequisites of inter-organisational knowledge sharing. Specifically, ability and motivation – both relative to the specific partner – have been identified as central determinants of knowledge-sharing. These are in turn contingent on the amount of shared context between the partners. But what determines shared context? And what are the particular benefits and liabilities from more or less shared context?

In this chapter, different forms of distance between the partners are introduced as important contextual variables. This ties in a recent debate in innovation research which questions the role of geographic proximity in the view of other, socio-economic or socio-cognitive linkages that draw individuals and organisations toward each other or distanciate them.

The basic ideas of this line of research are introduced in section 4.2. Corresponding to the multi-facet view of proximity/distance, different taxonomies have been developed in recent years. In section 4.3, the most prominent taxonomies are introduced, opposed and a framework for the current investigation is developed. One recent insight is that both proximity and distance are accompanied by positive (benefits) as

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well as negative effects (liabilities). As distant relationships in particular are praised for their enhanced potential for learning and novelty generation, section 4.4 discusses the benefits and liabilities of different forms of distance between the partners. Wherever available, the theoretical discussion is combined with insights from existing empirical studies. Moreover, as well as disentangling different forms and their effects, a central tenet of this line of thought is to investigate the relative weight, interdependence and interplay of different forms of proximity, respectively distance. These ideas are explored in section 4.5. Furthermore, two mediating variables that are thought to affect the impact of different forms of distance on inter-organisational co-operation – the co-operation stage and the learning rationale – are discussed in section 4.6. A summary of the main insights is provided in section 4.7.

4.2 Introducing Basic Ideas

Based on a critique of the canonical view in innovation research holding that geographic proximity is central for interactive learning and novelty generation, there are recent voices that advocate a closer investigation into the relationships and mechanisms that underpin innovative interaction (Gertler, 2006).[1] As response, different forms of proximity underpinning interactive learning and novelty generation have been offered.

This has been expressed most markedly by a school of thought known as 'Economics of Proximity' or 'Proximity Dynamics' (Carrincazeaux et al., 2008).[2] Critically reflecting the current popularity of geographic proximity as an all-embracing concept to explain interactive learning, firm inventiveness and the success story of certain regions, its proponents state an ambiguity in the term 'proximity', which is also used differently by different schools of thought.[3] Building on this insight, the goal is

[1] As a reason, Kirat and Lung (1999) propose that geographic proximity is the most 'intuitive' (p. 29) form of proximity that fits into the popular concepts of clusters (Porter, 1998), learning regions (Simmie, 1997), innovative milieus (Camagni, 1991) and creative fields (Scott, 2006).

[2] Important representatives of this line of thought are Broekel and Boschma (2009) as well as Boschma (2005a); Carrincazeaux et al. (2008) Torre and Rallet (2005); Pecqueur and Zimmermann (2004), Rallet and Torre (1999a); Gallaud and Torre (2004); Kirat and Lung (1999); Sierra (1997); Bellet et al. (1993).

[3] Compare the role of the 'social proximity' (Whittington et al., 2009, p. 91) in social network research or 'technological proximity' (Verspagen, 2005; Nelson & Winter, 1982, p. 497) within evolutionary economics.

to analytically distinguish different forms of proximity, endogenise geographic space into economic analysis, and thus explain the true underpinnings of interactive learning and novelty generation (Bellet et al., 1993).

Borrowing from social studies, two basic logics are thought to constitute important socio-economic or socio-cognitive forces underpinning tie formation, interactive learning and novelty generation, aside from the geographic location of actors:

- the **logic of belonging**, implying that 'co-operation will, a priori, develop more easily between researchers and engineers belonging to the same firm, the same technological consortium or the same innovation network' (Torre & Rallet, 2005, p. 50), and
- the **logic of similarity**, where interaction is facilitated if actors 'share a same system of representations, which facilitates their ability to interact' (p. 50).

These basic logics are in line with evolutionary tenets assuming that firms, being cognitively constrained, look for new ideas in their vicinity ('local search') – again in a multiple sense of the word – which underpins their observed path-dependent development (Boschma & Frenken, 2009; Nelson & Winter, 1982; March & Simon, 1958).[4]

However, while simultaneous proximity in different dimensions can constitute strong 'centripetal' forces leading to regional cohesion, their decoupling can constitute strong 'centrifugal' forces leading to non-localised or global network relations.[5,6]

[4] March and Simon (1958, pp. 138 ff.) refer to individual or organisational 'frames of reference' that influence creative thinking and problem-solving. These 'frames of reference' determine perceived alternatives and guide the choice among them in a specific situation, leading to localised search patterns.

[5] The terms 'centripetal' and 'centrifugal' forces are used to explain global location decisions in R&D (see e.g., Pearce, 1989, pp. 38 ff.; Granstrand, 1999, pp. 289 ff.). Centripetal forces are those forces that favour centralisation and concentration of R&D activities, while centrifugal forces comprise those forces that favour their dispersion and thus lead to the development of global networks of R&D. Note that these terms have already been used before in urban geography to explain those forces which encourage a movement of people, business and industry away from central urban areas (e.g., Colby, 1933).

[6] Examples are given in the early writings of Rallet and Torre (1999a), where they discuss historical and personal ties to be more decisive for tie formation than geographic proximity. They also observe that some public cluster initiatives failed to realise their initial goals as they could not induce co-operation into geographically co-located actors who did not share a common socio-cognitive sphere.

Moreover, proximity is currently perceived as supportive in some aspects; however, it can constitute a hindrance for other purposes. In particular, distance in some dimensions is currently perceived as important for invention and innovation due to its heightened learning and novelty potential (Boschma, 2005a,b). Boschma (2005b) underscores that 'it is increasingly recognized that proximity might have not only positive effects, but also negative effects for interactive learning and innovation' (p. 42). That is, a local search tendency can inhibit the in-flow of new ideas and diversity (Rosenkopf & Nerkar, 2001; Stuart & Podolny, 1996). Boschma and Frenken (2009) call this the 'proximity paradox' (p. 2). It is this trade-off that has been critically addressed of late, and that is also key to this thesis.

4.3 Different Forms of Distance

The insight of different forms of proximity underpinning interactive learning and novelty generation has led to different taxonomies of proximity, but also to different labels, definitions, interpretations and conceptual levels of analysis. Table 4.1 provides an overview of some of the most prominent taxonomies that are introduced and opposed in this section.[7]

The first publication that has opened the discussion on different forms of proximity for economic interaction has been provided by Bellet et al. (1993) in a special issue of the French scientific journal *Revue d'Économie Régionale et Urbaine*.[8] In this article, the authors underscored the productive combination of insights from scholars of industrial and regional economics and expounded a joint research agenda that implied: (1) centering the analysis on the productive system, primarily the creation of innovation; (2) integrating the historical dimension; (3) analysing interactions leading to collective learning, and (4) focusing on non-market relationships that imply the formation of public and private institutions. They further offer a provisional distinction into economic (the relationships within and between organisations, founded upon shared representations and practices) and geographic (metrical and time) proximity.

[7] Those dimensions which roughly correspond each other are included in the same line in table 4.1.

[8] Note that related ideas had already been presented in earlier writings in innovation research, particularly in Lundvall (1988). However, Lundvall never expounded them in depth.

Table 4.1: Different Taxonomies of Proximity

Source	*Bellet et al. 1993*	*Torre/Gilly 2000; Rallet/Torre 1999, 2009; Torre/Rallet 2005*	*Talbot/Kirat 2005; Talbot 2007*	*Zeller 2002, 2004*
Level of analysis	Organisations	Organisations, regions	Organisations, regions	Project teams (intra-/inter-organisational), multinational firms
Type of contribution	Conceptual	Conceptual/ empirical (case studies)	Conceptual	Empirical (case studies)
Taxonomy	Geographical Organisational	Geographical Organisational	Geographical Organisational Institutional	Spatial Organisational Institutional Cultural Relational Technological (Virtual)

Source	*Bouba-Olga/ Grossetti 2005*	*Boschma 2005; Boschma/Frenken 2009*	*Knoben/ Oerlemans 2006*	*Narula/ Santangelo 2007*
Level of analysis	organisations, individuals	Regional dynamics; inter-organisational networks	Inter-organisational collaboration	Inter-organisational co-operation
Type of contribution	Conceptual	Conceptual	Conceptual (meta analysis)	Empirical (survey data)
Taxonomy	Spatial	Geographical Organisational Institutional	Geographical Organisational Cultural	Geographical
	Relational	Relational	Social Technological	
	Resources (cognitive, material)	Cognitive	Cognitive	
				Strategic (Competitive)

Among the most prominent contributions that followed are those by Torre and Gilly (2000) and Rallet and Torre (2009; 1999a; 1999b) as well as Torre and Rallet (2005), respectively, who adopt an organisational perspective and a micro-analytic, bottom-up approach. In their contributions, they question the role of geographic proximity in the light of other forms of similar logics and shared governance, be it through cognitive proximity as found within professional communities or through a close co-ordination under the auspices of a central authority, such as a firm. According to Rallet and Torre (1999a, p. 4), this form of 'organised' or 'organisational' proximity is much more decisive and binding in collaboration than geographic proximity as such. Torre and Rallet (2005) define organisational proximity as 'the ability of an organisation to make its members interact' (p. 49). Their understanding of an 'organisation' is thereby a broad one, including 'any structured unit of relations. It might take any form of structure, e.g. a firm, an administration, a social network, a community and a milieu' (p. 58). For them, 'belonging to an organisation (in the widest sense of the term) – with its set of common rules – enables the members to share the same representations and values, which facilitates their coordination, even when [geographic] distance separates them.' (Rallet & Torre, 2009, p. 1). This questionable role of geographic proximity is reinforced in view of the current possibilities offered by information and communication technologies (ICT), or virtual proximity, and employee mobility, through which 'temporary geographical proximity' can be established (Rallet & Torre, 2009).

By contrast, Kirat and Lung (1999), Talbot and Kirat (2005) and Talbot (2007) adhere to a macro, top-down perspective and stress the role of institutional, next to organisational and geographical, proximity for organisational interaction. Institutions – defined as 'the assembly of agents as parties to a common space composed of representations, models and rules being applied to thought and action' (Kirat & Lung, 1999, p. 30) – are seen as important levers and enablers for interactive learning and innovation because they shape shared patterns of behavioural and cognitive rules.[9] Since institutions on a macro level support interactive links and tend to have a clear geographic boundary, institutions are perceived as marking the crossroads

[9] There is an ambiguity in the meaning and use of the term 'institutions' in the literature. While Talbot and Kirat follow North (1990), who distinguishes between institutions as the 'rules of the game' (p. 3) on a macro level and organisations as the 'players' (p. 4), others follow another interpretation. For example, Hodgson (2006) similarly defines institutions broadly as 'systems of established and prevalent social rules that structure social interactions' (p. 2). However, for him, organisations are a specific type of institution, having distinct boundaries, principles of sovereignty and possibilities for command. The distinction between institutions and organisations in the work of North is grounded in his foremost in-

of organisational and geographic proximity. In this sense, organisational proximity can develop only on the basis of institutional proximity, which in turn has a strong geographic boundary. For them, the coupling of these three dimensions is a strong argument for regional or national interaction.

Also Zeller (2004, 2002) draws on the idea of different forms of proximity in his case study of two large Swiss multinational pharmaceutical firms and their global organisation of R&D activities. Zeller (2002) investigates the proliferation of inter-functional and inter-organisational project teams, which are often distributed across different countries and continents. He perceives project organisations as a way to overcome functional, geographic and organisational boundaries, as they can create proximities of various kinds. In his 2004 contribution, Zeller refers to the notion of proximities to explain the localisation and subsequent embedding of multinational subsidiaries in foreign clusters. Here, a critical balance between proximity to the locale and to the corporate headquarter has to be striven for. To understand these processes of local embedding on the one side and internal integration on the other, Zeller draws on seven dimensions of proximity: spatial, organisational, institutional, cultural, relational, technological and virtual.

In a series of conceptual contributions, Bouba-Olga, Grossetti and Zimmermann distinguish between geographic and socio-economic forms of proximity (Bouba-Olga & Grossetti, 2007, 2005; Bouba-Olga, 2005; Bouba-Olga & Zimmermann, 2004). In Bouba-Olga and Grossetti (2005), they continue to divide socio-economic proximity into the categories 'proximity in resources' (either cognitive or material) and 'relational proximity'. They also distinguish between the level of the individual and the level of organisations, which helps to locate and understand important socio-economic forms of proximity. They particularly stress the role of social ties that

terest in the functioning of economic systems, not in intra-organisational rules. The level of abstraction depicting organisations as (atomistic) players is instrumental to his analysis of higher-aggregate phenomena (Hodgson, 2006, pp. 9-10). However, current authors deviate in their understanding of institutions and their relation to organisations. While also Talbot (2007) later acknowledges that organisational proximity is a particular form of institutional proximity, he sticks to the distinction in order to distinguish between 'the general role of institutions, and the more specific role of organisations' (p. 10). Thus, the distinction – which is also practised here (see sections 4.4.2 and 4.4.3) – mainly refers to different levels of analysis, from a collective, macro level of rules and conventions, to a meso or micro level of firms and other organisational forms (e.g., networks). Moreover, institutions on a macro level and organisations on a meso or micro level differ in their instruments to create and enact shared rules, norms and expectations. Thus, a distinction between the two levels is necessary.

are found at the level of individuals. For them, it is primarily the decoupling of individual social ties from the region, e.g., through employee mobility, that can lead to geographically distant relationships. Thus, relational networks extending the region are perceived as the prime reason for international co-operation (Bouba-Olga & Grossetti, 2007).

Boschma (2005a) – in a special issue of the journal *Regional Studies* from February 2005 on the 'Role of Proximity in Interaction and Performance' – gave the discussion on the different forms of proximity a new impetus. His main contribution lies in a further disentanglement and thorough definition of different forms of proximity and a discussion of their effects on co-ordination, interactive learning and innovation as well as their inter-relationships. Trying to achieve a minimum of overlap, he distinguishes between five dimensions of proximity: geographical, organisational, institutional, relational and cognitive. His taxonomy has found widespread appeal due to its analytical sharpness. Further, Boschma introduces a critical stance on the benefits of proximity, arguing in favour of a productive mix of proximity and distance in order to leverage the innovative potential of ties: too proximate relations in any of the dimensions might lead to a lack of novelty, inertia and lock-in; too distant relations, however, risk misunderstandings and forward opportunistic behaviour. This discussion has been extended in a more recent contribution, where the trade-off between proximity and distance is referred to as 'proximity paradox' (Boschma & Frenken, 2009, p. 2). While the first paper investigates regional dynamics, the second turns to inter-organisational networks.
Narula and Santangelo (2007) provide an important amendment, addressing the interplay of geographic proximity and competition. They propose and empirically demonstrate that competitors who are geographically proximate use co-operation to control knowledge leakage and to protect core competencies rather than to support knowledge sharing by channeling information to outside sources.[10]

Finally, Knoben and Oerlemans (2006) provide a first meta-analysis of the literature on different types of proximity. They summarise and compare existing concepts with

[10] Narula and Santangelo (2007) do not position themselves in the work of Economics of Proximity. However, it became evident that some proponents of this school mix technological proximity or distance with the strategic dimension, presupposing that technological proximity leads to rivalry (e.g., Broekel & Boschma, 2009). However, preliminary interviews have shown that this is not necessarily the case: different technological approaches can be rivalling, whereas the same technological approach can be used in different ways and for different markets or customers. Thus, it is reasonable to separate the two dimensions.

the intent of reducing the ambiguity that the manifold contributions, each developing its own taxonomy, have brought into the discussion. From the existing literature, they identify seven distinct dimensions of proximity: geographical, organisational, institutional, cultural, social, technological and cognitive. They conclude that 'the concept of proximity suffers from a certain degree of conceptual ambiguity' (p. 79), as:

- different labels are used for identical dimensions of proximity (e.g., geographical and spatial proximity);
- blanket dimensions are used (e.g., non-spatial proximity);
- different dimensions show large amounts of overlap and cannot be entangled (e.g., cultural and institutional proximity);
- different definitions exist of the same dimension of proximity; and
- dimensions of proximity are used at different levels of analysis (e.g., at a cluster, network or dyadic level).

In a later contribution, Knoben and Gössling (2009) further criticise current uses of the proximity concept within co-operation research for not being specific about the form of inter-organisational co-operation the respective researchers have in mind (see section 1.4). They suggest that temporary forms of inter-organisational co-operation, such as inter-organisational projects, differ in their characteristics from long-term forms, such as alliances or joint ventures. They expect that inter-organisational co-operation projects are characterised by heightened challenges compared to other forms of inter-organisational co-operation due to their temporary character, usually integrating different bodies of expertise and people who might never have met before and might never meet afterward. Thus, they might be more dependent on different kinds of proximity between the partners.

The assertion of a confusing state of the concept of proximity, not only in regard to the various taxonomies of proximity dimensions, but also in the non-conformity in their labelling, content and interpretation, is shared. As systematic empirical studies are mostly lacking, the question posed by Knoben and Oerlemans (2006) – 'which dimensions of proximity are relevant in inter-organisational collaboration and how are they defined?' – is still not answered and remains only theoretically and conceptually debated.[11] What is learned from these opposing views is that a clear definition and discussion has to be provided to reduce overlap and prevent confusion. However, it is also not the goal to create another additional taxonomy. For this reason, the taxonomy used here mostly draws on Boschma (2005a), who has provided a thorough deconstruction with the explicit intention of minimising overlap in the dimension. However, due to a different unit of analysis investigated here, other interpretations are used wherever needed.

As a conclusion from this survey, a taxonomy of six forms of proximity, respectively distance between the partners, is developed: **geographic**, **institutional**, **organisational**, **strategic**, **technological** and **relational**. It represents a comprehensive synthesis of contemporary dimensions, fusing those dimensions under one category that are perceived as similar or highly comparable (table 4.2).

The first column in table 4.2 summarises the six forms that are core to the following analysis; the second column includes a list of terms that are closely related and often used interchangeably in the literature.

Table 4.2: Synthesising existing Taxonomies of Proximity

Dimension	Equivalents in the literature
Geographic	Spatial, Physical (virtual)
Institutional	Cultural
Organisational	Organised
Strategic	Competitive
Technological	Cognitive, in resources
Relational	Social, Personal

[11] Knoben and Oerlemans conclude from this stated lack of clear discriminatory power of the dimensions a return to the initial broader conception of proximity in three categories: geographical, organisational and technological. However, this conclusion is not shared here as the strength of deconstructing individual forms to analyse their importance and differential effects is appreciated. As Boschma (2005b) notes, ‘it is essential for analytical reasons to clarify and define the different dimensions of proximity ... in such a way that overlap is avoided, and research can assess the effects of each dimension ... on interactive learning and innovation’ (p. 42).

This taxonomy is used as a template to analyse *distant* relationships and explore their learning and novelty potential from an innovation perspective. This is in line with the 'proximity paradox' (Boschma & Frenken, 2009, p. 2) for learning and novelty generation that is recently highlighted in the literature (Boschma & Frenken, 2009; Knoben & Oerlemans, 2006; Boschma, 2005a; Rosenkopf & Almeida, 2003).

4.4 Distant Relationships: Definitions, Effects, and Evidence

In the following sections, each form of distance is introduced and discussed in detail. The sections follow a tripartite structure, commencing with a definition, which is followed by a discussion of potential effects in regard to learning and novelty generation – more specifically its contribution to novelty and its impact on the ability and motivation to share knowledge – and closes with a summary of existing empirical evidence. On this basis, hypotheses on individual effects, relative weights and interaction effects of different forms of distance are drawn in Chapter 5.

4.4.1 Geographic Distance

Definition and Characterisation

Boschma (2005a) provides the following definition of geographic distance:[12]

> '... *spatial or physical distance between economic actors, both in its absolute and relative meaning.'* (p. 69)

This definition embraces geographic distance between two actors in an 'absolute' as well as a 'relative' sense. Because of processes of globalisation accompanied and

[12] Other authors use the terms 'spatial' or 'physical distance' next to 'geographic distance'. Here, the term 'geographic distance' is preferred; it is also the most commonly used term. 'Spatial distance' is misleading insofar as any of the dimensions are perceived as spatial, while 'physical distance' evokes a bodily presence, which can also be of a temporary nature, and neglects infrastructural components of the dimension (Bouba-Olga & Grossetti, 2005).

fuelled by new means of information, communication and travelling, geographic distance is currently no longer adequately captured in absolute metrical terms alone, such as the number of kilometers separating the partner organisations. It is now rather perceived as a function of the time and costs needed to interact across geographic distance, both in a real and a virtual sense (Torre & Rallet, 2005; Bouba-Olga & Grossetti, 2005; Gilly & Wallet, 2002).

Furthermore, Torre and Rallet (2005) suggest that geographic distance is subjective in that it proceeds from a personal judgment made by individuals. This judgment is based on an evaluation of objective data (kilometers, time and costs) together with the personal perception the individual has of geographic distance. This perception can vary among individuals, depending on personal and social characteristics such as age, social background, profession and experience.

Thus, geographic distance is better understood as both an absolute and a relative construct, describing the overall (factual and perceptual) accessibility of the partner (Coenen et al., 2004). This accessibility encompasses the existence of an adequate transportation and communication infrastructure, the presence of time zone differences between the partners and the personal judgments of those involved (Jyrämä et al., 2009; Olson et al., 2009; Moodysson & Jonsson, 2007; Bouba-Olga & Grossetti, 2005; Torre & Rallet, 2005; Gilly & Wallet, 2002).

Effects of Geographic Distance on Inter-Organisational Co-operation

Geographic distance between the partner organisations is thought to affect knowledge sharing in co-operative R&D in various ways. Generally, it can be assumed that geographically distant partners are sought for particular reasons. These might be quality reasons, the partner's unique fit in resources and capabilities, or a particular novel approach or perspective offered by the partner. Lately, innovation researchers increasingly stress the importance of extra-regional as well as extra-national ties to access novelty and enrich the firm with 'external economies of cognitive scope' (Nooteboom, 2009; Belussi et al., 2008; Lorentzen, 2008; Kim & Song, 2007; Nair et al., 2007; Shipilov et al., 2007; Lavie & Rosenkopf, 2006; Boschma, 2005a; McKelvey, 2004; Coenen et al., 2003). Others suggest that a strategy of choosing the 'global best' (Dahlander & McKelvey, 2005, p. 413) partner needs to consider any geographic scale. Seeking new external impetus or pursuing a strategy of going for the 'global best' partner rather than going for the 'next' partner might imply that a firm needs to incur considerable geographic distance.

This strategy is enabled through advances in ICT and a global transport infrastructure; as these support other forms of proximity, such as 'virtual proximity' (Zeller, 2004, p. 84) or 'temporary geographical proximity' (Rallet & Torre, 2009). Due to these possibilities, some scholars even postulate a 'death of distance' or 'death of geography' (Cairncross, 1997; Martin, 1996, cited from Morgan 2001).[13]

On the other hand, co-operation in R&D rests primarily on the sharing of tacit, individual or collective and contextual knowledge, which has traditionally been a strong argument for geographic proximity (Asheim & Gertler, 2005; Koschatzky, 2001).[14] Thus, through geographic distance between the partners, difficulties in the sharing of tacit, contextual knowledge can arise that might affect both the ability and the motivation of those involved to share knowledge with and absorb knowledge from the partner. Three impacts of geographic distance are thought to exert a negative effect on the **ability** to share knowledge: (a) a reduced *frequency of interaction*, (b) changing means and hence *quality of interaction* and (c) increased *costs of interaction.*

Next to a lower likelihood for chance meetings, it has been observed empirically that the *frequency of interaction* decreases with growing geographic distance. This 'distance-decay' effect between geographic distance and communication frequency has initially been established already in the 1970s by Allen (1977), who observed a logarithmic decline in communication frequency between engineers and scientists with growing geographic distance between them. Hough (1972) established a comparable relationship between geographic distance and communication frequency in an analysis of communication patterns between R&D sites in the home country of a firm and its sales subsidiaries in foreign locations. However, owing to the great advances in ICT in recent years, communication across geographic distance has been

[13] Modern ICT are regarded as 'the technologies of globalization' (Archibugi and Michie 1997b, p. 4) or as 'time and space shrinking technology' (Lorentzen, 2008, p. 533). Thus, it is attributed important centrifugal or dispersive effects on economic interaction (Maignan et al., 2003; Arundel & Geuna, 2001).

[14] Asheim and Gertler (2005) note: 'when one combines these two features of the innovation process – the centrality of "sticky", context-laden tacit knowledge and the growing importance of social interaction – it becomes apparent why geography now "matters" so much' (p. 293).

drastically eased. Already Hough (1972) expected the wide introduction and use of computers to improve the 'effective distance' (p. 3) between interacting parties. Nonetheless, Kraut et al. (1990) as well as Boutellier et al. (2000) suppose that the distance-decay function is still valid, although having moved to another level (figure 4.1).[15]

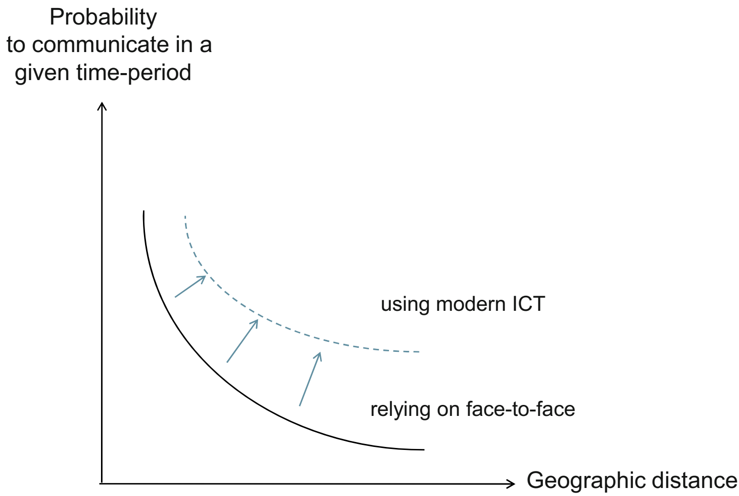

Figure 4.1: Distance-decay Function and the Effect of Modern ICT (adapted from Boutellier et al. 2000, p. 188)

Furthermore, different time zones have been reported as important barriers to frequent and timely communication (Olson et al., 2009; Sapsed & Salter, 2004).

Next to the frequency of communication, a shift in the means of communication has already been addressed, eventually affecting the *quality of interaction*. Interaction with geographically distant partners tends to rely more extensively on

[15] Similarly, Gertler (1995) finds in an analysis of user-producer interaction in the adoption of new process technologies in the Canadian advanced machinery sector that the likelihood of site visits declines as the geographic distance between user and producer increases. This observed distance-decay was particularly strong in the case of small buyer firms.

electronic means for communication at the expense of face-to-face communication (Howells, 1995). On the one hand, ICT constitutes an important enabler without which regular and timely interaction at geographic distance would hardly be feasible at all. It might also increase the flexibility in communication where communication partners are physically as well as temporally separated (Rallet & Torre, 1999b). Furthermore, barriers to approaching another person can be reduced by resorting to non-personal means of communication such as email (Schneider & Barsoux, 2003). Moreover, there exists a wide array of different communication media, ranging from email, telephone and teleconferencing to videoconferencing. These differ in terms of their 'richness', defined as their capacity to transport complex, contextual and tacit knowledge (Picot et al., 2003; Daft & Lengel, 1984).

However, on the other hand, at the same time that these media for information and communication become more sophisticated and 'rich', it is argued that all information necessary to share tacit knowledge and especially 'know-how' can never be fully externalised and transmitted via ICT (Johnson et al., 2002).[16] In particular, codification as a means to convey knowledge through written messages risks being incomplete or distorted (D'Agata & Santangelo, 2003; Johnson et al., 2002). Johnson et al. (2002) argue that 'it is very seldom that a body of knowledge can be completely transformed into codified form without losing some of its original characteristics' (p. 246). Although more interactive media exist that allow for a more content- and context-rich information transfer, they do not fully capture tacit and contextual elements of knowledge, the sharing of which still depends on close personal interaction, combining verbal explanation with demonstration (Rallet & Torre, 2009). Thus, employing ICT as a central tool for knowledge sharing risks losing key elements, including body language and gestures, feelings, intuition and context, all of which play a great role in the sharing of tacit knowledge (Jyrämä et al., 2009; Morgan, 2004; Hinds, 1999). As central parts of knowledge are potentially dismissed, the probability for misunderstandings, false interpretation, reduced learning and finally frustration rise. Likewise, Johnson et al. (2002) argue that the benefits and costs of ICT are associated with the amount of knowledge lost in the transformation process from tacit to codified as well as the costs of codification. It is assumed that 'it is often more efficient and less expensive to rely on tacit knowledge exchanges than to codify knowledge in order to transfer it easily' (Rallet & Torre, 1999a, p. 374).

[16] The difficulties in externalising tacit knowledge have been expounded in Section 3.2

Finally, technical constraints add to the net effect of ICT on the quality of communication over geographic distance: the transfer rates of more complex communication tools such as videoconferencing are still not a satisfactory substitute for face-to-face interaction. Moreover, interfaces between different ICT tools used by otherwise unrelated partners as well as network security might be new emerging problems (Boutellier et al., 2000). Although the costs of using ICT have significantly decreased over the last decade, there are huge differences in quality and costs for professional equipment that need to be calculated when considering collaboration at geographic distance. Together, Allen and Henn (2006) conclude that ICT do not fully substitute for face-to-face communication. Instead, the two are contingent upon each other: effective interaction via ICT can be used only by individuals who also meet frequently (Rallet & Torre, 2009, 1999b; Morgan, 2004).

However, bridging geographic distance via both ICT as well as mobility leads to an increase in the *costs of interaction*. Subsumed are costs of traveling and potential costs for the establishment of compatible ICT infrastructure (Picot et al., 2003, p. 63). Furthermore, Boutellier et al. (2000) add opportunity costs due to a lack of alternative productive use of the time lost in traveling, as well as social costs, as extensive traveling is linked to personal strain on employees. Particularly for SMEs, new means of ICT can significantly reduce the entry barriers for global co-operation, offering fast and relatively cheap means for communication with geographically distant partners. However, they are also restricted in the resources they can mobilise for traveling as well as for appropriate ICT equipment. Often, managers are personally involved in the operation of the business as well as the inter-organisational co-operation, and their expertise is needed at various ends of the firm. Accordingly, their opportunity costs are comparably high. These arguments tie in with the impact of geographic distance on the **motivation** to co-operate.

Moreover, geographic distance can be accompanied by higher levels of perceived relational risks and lower levels of trust in the partner (Rocco et al., 2000; Hildreth et al., 1999). Rocco et al. (2000) investigated how trust is perceived among employees within a globally distributed intra-firm network of software development teams. Distinguishing between emotional trust, defined as non-calculative and spontaneous emotional bonds, and cognitive trust, understood as judgments of competence and reliability of the partner, they found that emotional trust especially suffers from geographic distance. The results are less pronounced for cognitive trust. This finding points to a ‘trust-decay’ function with the level of trust decreasing with increasing geographic distance between the partners. One explanation forwarded by Rocco et al. is that less face-to-face contact and a switch to less personal communication media affect the level of trust in the partner. Thus, the claim forwarded by Handy (1995, p. 45) that 'trust needs touch' seems to apply. Close geographic proximity, by contrast, allows actors to meet more frequently in order to build trust as well as to 'monitor each other constantly, closely and almost without effort or cost' (Maskell & Lorenzen, 2003, p. 15).

Relatedly, geographic distance has been reported to slow down communication and consensus making (Cummings & Kiesler, 2007). Accordingly, significant delays in new product development and market entry have been witnessed (Herbsleb et al., 2001; Rocco et al., 2000). Also, a problem or decision at one location may go unnoticed by researchers at the other location. Kraut et al. (1990) observe that minor decisions in the course of collaboration tend to be shared with geographically proximate partners, whereas researchers tend to solve them alone if the partner is situated far away. Rather, decisions tend to be made in informal circumstances, leaving remote colleagues in the dark (Sapsed & Salter, 2004; Rocco et al., 2000). This likewise reduces trust and increases the likelihood of conflict. Together, a lack of trust not only increases the transaction costs of contracting and monitoring, but also affects the motivation to share knowledge.

Taken together, there is currently both enthusiasm for the 'time and space shrinking' potential of ICT, as well as a return to the canonical view of the region as the prime point of reference, primarily to support interactive learning and novelty generation based on the combination of tacit knowledge. It is suggested that 'virtual' and 'temporal geographical proximity' might substitute for permanent co-location of co-operation partners. However, some arguments have been forwarded which underscore the benefits of geographic proximity. These were a reduced frequency of interaction, less content and context-rich media, increased costs of interaction, potential delays in project time lines, greater personal strain accompanied by lower levels of trust in the partner.

The discussion has also suggested that geographic distance is only indirectly related to the ability, in terms of *cognitive* ability, to share knowledge, primarily affecting the frequency, means, costs and motivation for knowledge sharing. This is in line with Boschma (2005a), who suggests that geographic proximity has at most an indirect effect on knowledge sharing; its effect being contingent on other forms and expressions of distance (see section 4.5). Centrally, the effectiveness of ICT communication will depend on the amount of shared context between the partners in regard to the other dimensions of distance (sections 4.4.2 to 4.4.6).

Empirical Evidence

Following Jaffe et al. (1993), a number of studies have investigated the geographic reach of inter-organisational co-operation activities and the pace of knowledge diffusion. Work in this tradition has generally come to the conclusion that knowledge diffuses more slowly across large geographic distance than it does in the immediate neighbourhood (Fabrizio, 2006; Audretsch & Feldman, 1996; Katz, 1994). These results have been reaffirmed by Meder (2008), who used patent data from German firms to investigate the influence of geographic distance on the likelihood for co-operation formation. He finds geographic proximity to be a predictor of the likelihood of any two organisations engaging in inter-organisational co-operation. Recently, Laursen et al. (2010) refined these findings, arguing that firms' decisions to collaborate with universities are influenced by both geographic proximity and the quality of the universities. The findings from a sample of UK university–industry collaborations show that the quality of the university is an important intermediary variable to predict university–industry collaboration. Thus, being located close to a lower-tier university reduces the propensity for firms to collaborate locally, while co-location with top-tier universities promotes collaboration. Moreover, they found that, if offered the choice, firms give preference to the research quality of the university over geographical proximity. This finding is in line with recent studies witnessing a farther geographic reach of inter-organisational activities (e.g., Belussi et al., 2008; Waxell & Malmberg, 2007; Coenen et al., 2004; Dahlander & McKelvey, 2005).

However, next to its effect on co-operation formation, how does geographic distance impact during the co-operation? The actual effect of geographic distance within inter-organisational co-operation, and for knowledge sharing more specifically, has received less attention to date. One notable exception is the contribution by Mora-Valentin et al. (2004). In an analysis of the success factors in firm–university co-operation of Spanish firms, they address the role of geographic distance more thoroughly, with the limitation that their focus is on *national* co-operation projects. They raise the geographic distance between the partners as an absolute metrical as well as a relative variable; i.e., the time it takes the partners to travel for face-to-face meetings. From the results of a multivariate analysis, they conclude that geographic distance is not a significant predictor of the success of the co-operation.

Moreover, empirical studies investigating the success factors for inter-organisational co-operation often include a country dummy variable to control for country effects. Doing this, these studies do not specifically account for geographic distance in a metrical or relative sense. Besides, institutional or cultural differences are not separated from geographic distance. For example, Gomes-Casseres et al. (2006) distinguish between alliances that extend or that are situated within the Triad region, and found that geographic proximity thus defined has a positive effect on knowledge sharing and learning within co-operation. Shipilov et al. (2007) investigated the impact of non-local ties on firms' performance in terms of their market share. They show that non-local ties have a negative impact on a firm's performance. Only with repeated ties, these negative effects eventually turn positive and the firms can recoup their initial investments in non-local ties. Similarly, Kim and Song (2007) observe a negative, although non-significant, effect of international compared to national co-operation on the generation of joint patents as an output measure for successful inter-organisational co-operation.

Research investigating geographically dispersed or virtual teams provides further evidence, generally suggesting that co-located work groups tend to perform better than those where group members are geographically dispersed (e.g., Gibson & Gibbs, 2006; Hinds & Mortensen, 2005; Hinds & Bailey, 2003; Sapsed & Salter, 2004; Kiesler & Cummings, 2002; Olson & Olson, 2000; Hildreth et al., 1999). Based on their extensive studies of collocated and remote teams, including questionnaires, interviews and on-site observation of different teams, Olson and Olson (2000) observed remarkable productivity advantages of collocated over remote teams. They concluded that ICT would never make up for the incommensurable rich means for interaction that (permanent) face-to-face contact offers. This finding was corroborated in a quantitative study by Gibson and Gibbs (2006); they found a significant negative relationship between geographic dispersion of a team as well as the degree of the team's dependency on electronic communication and innovation. Similarly, Hinds & Mortensen (2005) and Hinds & Bailey (2003) reveal higher occurrences of conflict in dispersed teams. Moreover, Hildreth et al. (1999) provided further interesting insights: for a research group within a multinational enterprise situated at two sites (UK and US) who met twice a year face-to-face and in between these meetings resorted to electronic media for communication, they observed that 'after a period of time the relationship "decays" until the next face-to-face meeting' (p. 351). This observation supports the distance-decay function as presented in figure 4.1 and its validity despite the possibilities provided by ICT.

Taken together, the current evidence of the impact of geographic distance on inter-organisational co-operation, particularly on successful knowledge sharing, is fractional and existing studies often build on crude measures of geographic distance. However, it generally points to a negative effect of geographic distance within inter-organisational co-operation.

4.4.2 Institutional Distance

Definition and Characterisation

Drawing on Boschma (2005a), institutional proximity refers to

> *'... the institutional framework at the macro-level. [... It] includes both the idea of economic actors sharing the same institutional rules of the game as well as a set of cultural habits and values.'* (pp. 67-68).

Institutional distance is the inverse of institutional proximity. It is understood as the degree of dissimilarity of the 'rules of the game' that characterise the institutional frameworks within which the partner organisations operate.
Its definition builds on the work of Douglass C. North (1990), a representative of Institutional Economics, who considers institutions as important structuring elements of social and economic processes within a society. He defines institutions as 'rules of the game in a society, or, more formally, ... the humanly devised constraints that shape human interaction' (p. 3). Institutions are conceptually distinguished from organisations as the 'players' (p. 4) of the game. The latter can be firms, individuals, governmental bodies and the like. North continues to distinguish 'formal' institutions, such as the prevailing law system, from 'informal' ones, such as culture, ethics and conventions that structure individual cognition and codes of behaviour (p. 4). Institutions are cumulative and follow characteristic historical paths. They are shaped in long-term processes of change and adaptation and thus help to create

stable expectations (Hodgson, 2006).[17]

National culture as one pillar of the institutional set-up of a country is perceived as having a particularly strong influence on economic interaction within and between organisations. Hofstede (1980) defines national culture broadly as 'the collective programming of the mind which distinguishes the members of one group or category of people from another' (p. 5). Geletkanycz (1997) offers a narrower definition of national culture as 'the common frame of reference or logic by which members of a society view organisations, the environment, and their relations to one another. National culture is likely to yield important effects on the process by which the environment is known and responded to' (p. 617). Social anthropologists have long investigated the central dimensions along which different national cultures can be categorised and evaluated. Hofstede (1980, 1991), for example, classifies national cultures along the dimensions of uncertainty avoidance, power distance, individualism/collectivism and masculinity/femininity. Perlitz (2004) adds assumptions about time (monochronic/polychronic), place, language (high-context, low-context), cognitive processes (analytic/synthetic, deductive/inductive, rational/analogical) and religion.

However, individual heterogeneity in cultural expressions is likely to exist within a national culture. For example, individuals can differ in one or several cultural traits based on their age, profession, or international experience. That is, around the population mean that defines a country-specific stereotype in regard to a specific cultural trait, there exists variation, with individual people being positioned more or less close to that mean expression (Schneider & Barsoux, 2003). This can be visualised in a normal curve, positioning the population of a country on a continuum with the end points as pole expressions of a specific characteristic (figure 4.2).
The majority of people from a particular country will be positioned at or close to the population mean; however, there can be more or less variance around the mean. Greater or lower levels of homogeneity within a country lead to flatter or steeper

[17] Despite processes of globalisation, manifest in close cross-border interaction, processes of imitation and at least partial convergence, it has been observed that different institutional set-ups tend to remain remarkably distinct over time (Bartholomew, 1997; Archibugi & Pianta, 1992). Also Hofstede (2001) notes that 'national cultures are extremely stable over time' (pp. 34-35). In a series of publications, Ralston and colleagues (Ralston et al., 1999, 1997, 1993; Egri & Ralston, 2004) investigate the convergence versus divergence hypothesis and argue for an intermediate ground, named 'crossvergence'. Crossvergence as a concept reconciles both extremes of convergence and divergence and argues that both phenomena co-exist where some values are more likely to converge while others are stronger dominated by national cultures. Moreover, they observe that not all values change at the same rate.

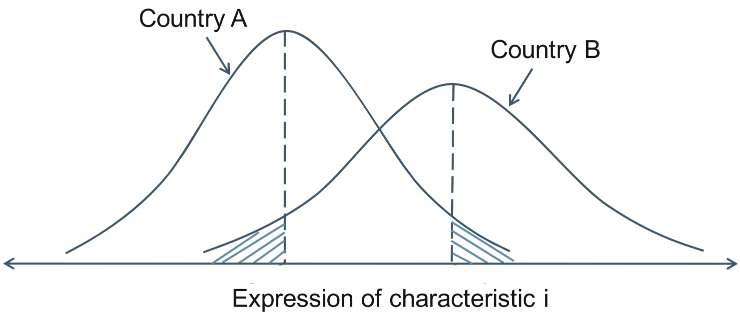

Figure 4.2: Cultural Normal Curves (adapted from Schneider & Barsoux, 2003, p. 15)

normal curves. Schneider and Barsoux (2003) compare the USA with Japan, the first being perceived as very heterogeneous, with more internal variation and a flatter curve line, and the latter being perceived as more homogeneous, with less variation and a steeper curve. Moreover, individual migration and culturally mixed countries dilute the distinctive power of national confines (Tung, 2008).

Yet, all in all, institutions constitute the framework within which economic and social interaction takes place. They are imprinted – to a higher or lower degree – on individuals and organisations, and thus define incentives, shape perceptions, guide behaviour and simultaneously constrain freedom of action (Talbot, 2007; North, 1990). Furthermore, divergent institutional set-ups can explain differential performances of economies over time.[18]

[18] These insights from Institutional Economics form an important pillar of Innovation Systems literature, such as 'National Systems of Innovation' (Nelson, 1993; Lundvall, 1992; Freeman, 1987) and 'Regional Systems of Innovation' (Cooke, 2005; Cooke et al., 1997). The concept of 'National Systems of Innovation' focuses on the jurisdictional boundary as defined by nation states. The concept was introduced by Freeman (1987) and further advanced and promoted by Lundvall (1992) and Nelson (1993) who observed different national performance levels due to differences in the institutional set-up of countries. The concept of 'Regional Systems of Innovation' is a derivative that was introduced by Cooke (2005) and Cooke et al. (1997). Together with a re-emphasis on regional territories in the 1990s, these sub-national units are stressed as important 'islands of innovation' (Trippl, 2009; Simmie, 1998) in a globalised world characterised by their own unique institutional set-up. However, their territorial boundary is much fuzzier and regional innovation systems build more on informal institutions among organisations than the concept of national systems of innovation

Expected Impact on Inter-Organisational Co-operation in R&D

Co-operation partners who have been socialised in their respective institutional contexts will bring their distinct capabilities, but also their characteristic views and patterns of behaviour, into inter-organisational projects. This can be beneficial in that resources, knowledge and capabilities from institutionally distant partners promise to yield varied insights. However, this can also lead to difficulties and friction in the process of collaborating.

It has been observed that institutions influence the trajectory of scientific, technological and economic development in unique ways (Morgan, 2004; Pavitt & Patel, 1999; Bartholomew, 1997; Nelson, 1993; Lundvall, 1992; North, 1990; Freeman, 1987). They can favour or restrain certain technological developments due to historical strengths/weaknesses or by providing specific incentives/disincentives (economically, technologically, legally, financially or morally). This eventually leads to different national strengths in particular scientific and technological fields and idiosyncratic trajectories within these. A combination of these distinct capabilities and strengths within inter-organisational co-operation can contribute resources that might not be available in the home innovation system. Similarly, a lack of adaptability, or inertia, of the home innovation system has been observed to impel innovative firms to exit the home system and find a more favourable framework in another innovation system, either via FDI or via co-operation with host organisations (Lange, 2009; Fernández-Ribas & Shapira, 2009; Narula, 2003).[19]

Next to different national scientific and technological strengths that can be combined, it has been suggested that cultural diversity itself can contribute to creativity, learning and novelty generation through the combination of differential views, perceptions and approaches as well as processes of recontextualisation (Stahl et al., 2010; Fernández-Ribas & Shapira, 2009; Becker-Ritterspach, 2006; Schneider & Barsoux, 2003, see also section 3.2). For example, distinct characteristic traits and capabilities are often ascribed to certain cultures. Boutellier et al. (2000) cite British inventiveness, Swiss and German systematics, Italian design orientation and American and

does. Despite their stated territorial boundary, innovation systems are in essence capturing institutional boundaries (Rallet & Torre, 1999a).

[19] Narula (2003) describes co-operation as a way for SMEs to circumvent disadvantages from unfavourable home innovation systems. Having neither the means for greenfield investments in other innovation systems, nor the power to shape their home innovation system to their advantage, this exit strategy might be their only way to stay competitive.

Japanese pragmatism. Blending these different strengths within an R&D project can combine the best of each trait and yield highly creative solutions. In this regard, Boschma (2005a) expects access to partners in other institutional settings to open up new avenues or perspectives for R&D.[20]

However, Boschma (2005a) continues to argue that 'a common language, shared habits, a law system securing ownership and intellectual property rights, etc., all provide a basis for economic coordination and interactive learning' (p. 69). This argument is a central tenet within institutional economics and national systems of innovation (Talbot, 2007; Freeman, 1987; Lundvall, 1992; Nelson, 1993). Thus, a lack in institutional proximity is assumed to hamper co-ordination, interactive learning and novelty generation, affecting both the ability and the motivation to share knowledge. Specifically, an institutionally diverse inter-organisational team may be confronted by differences in attitudes, values, behaviour, expectations and language (Schneider & Barsoux, 2003).

In regard to potential barriers in the **ability** of partner organisations to share knowledge, Lundvall (2010) assumes that 'the general institutional framework – including norms and codes – represents a context for communication, and individuals and organisations will decode information in accordance with this context. When cultural differences are present, certain types of messages will be difficult to transmit' (p. 59). These difficulties in communication when cultural differences interfere have been formalised by Haworth and Savage (1989) in their 'Channel-Ratio Model of Intercultural Communication'. The model is presented in figure 4.3 below.
It builds on classical communication models that differentiate between a sender and a receiver of a message, who are connected by a communication channel. Surrounding the sender and the receiver, depicted in circles, are their respective 'phenomenal fields' (p. 236), which are defined by their cultural belonging. The size of the intersection area of the circles represents the degree of overlap between the respective cultures of the sender and the receiver. The communication channel between them is separated by a share of explicit and implicit message conveyed by the sender and a share of apprehended and inferred message on the part of the receiver.[21] Thus, communication situations differ in the level of information conveyed explicitly or

[20] Accordingly, novel ideas might stem from institutional distance within a project rather than from mere geographical distance between the partners (Boschma, 2005a; Phene et al., 2006).

[21] Note that Haworth and Savage (1989) use the term 'implicit' rather 'tacit'. These terms are mostly used interchangeably in the literature (Rolf, 2004)

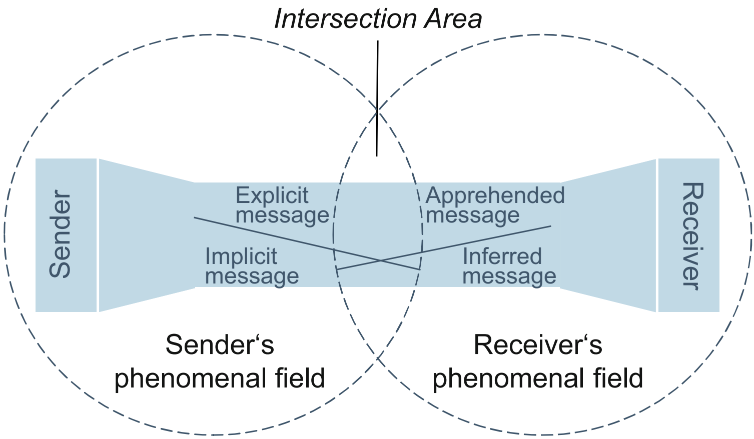

Figure 4.3: Channel-Ratio Model of Intercultural Communication (adapted from Haworth & Savage 1989, p. 236)

implicitly and the degree of apprehension and inference on the side of the receiver. The lower the overlap of the phenomenal fields, the more likely it is that misunderstandings will occur.

The model is constructed in a way to guide the applicant in determining the level of explicit message needed in any specific communication situation: the downward slope of the ratios between explicit and implicit as well as the upward slope between apprehended and inferred message and their respective levels at the point of entrance into the intersection area determine the amount of explicit message needed for effective communication. That is, the less the overlap in the sender's and the receiver's phenomenal sphere, the higher the level of explicit information needed to infer meaning by the receiver. However, the determination of the size of the intersection area and the optimal level of explication needed is based on subjective assumptions by the sender. These need not necessarily mirror the objective level required for effective communication by the receiver.

Mistaken assumptions and hence mismatches in the ratio of the explicit and implicit content of a message will be amplified when cultures meet in inter-organisational co-operation that differ in the degree of explicit/implicit ratios they usually refer to, designated as either 'high-context' or 'low-context' cultures (Perlitz, 2004; Hall & Hall, 1990). In high-context cultures, such as Japanese or Chinese ones, the meaning of a message depends heavily on the accompanying stimuli, on gestures and symbols. In low-context cultures, of which Germany and the Scandinavian countries are examples, written or verbal messages fully capture the meaning. Being confronted with a high-context or low-context partner will determine the remaining tacitness in a message. Moreover, what can be articulated in some languages cannot be articulated in others (Rolf, 2004). Coupled with the general difficulties in expressing tacit as well as emerging knowledge, communication difficulties are assumed to amplify.

The discussion so far dismisses general language differences between cultures, which can add to the difficulties in inter-cultural communication. Despite the fact that English is a broadly used and accepted business language, the level of English proficiency and fluency tends to differ between cultures. Thus, misinterpretations and misunderstandings can occur due to differences in the mastery of a language. This can be particularly troublesome when emerging knowledge – such as the case in R&D projects – is core to the communication situation, for which a general codebook does not yet exist or is not yet widely diffused.
Next to the ability of those involved to share knowledge, institutional distance between the partners can also exert a negative influence on their **motivation** to invest in knowledge sharing. First, institutions serve to stabilise economic and social interaction, by offering a set of formal sanctioning mechanisms as well as informal norms of conduct (Talbot, 2007).[22] They shape the inclination toward, opportunities for, as well as the consequences to be expected from opportunistic behaviour (Zylbersztajn, 2006; Williamson, 1991). Thus, shared institutions render predictable the actions of the partner – particularly when not clearly specified ex ante – as well as the consequences thereof, which can in turn increase the level of trust in the partner. Crossing institutional, and primarily jurisdictional, boundaries might (a) lead to difficulties in the enforcement of proprietary rights, and (b) increase the general insecurity and perception of relational risks through unfamiliarity with conventions and norms of the partner. Thus, the higher the distance between the partners' institutional set-ups, the less behavioural expectations will be met, the higher the insecurity and the higher the risk is perceived to be. This might lead to suspicion and an overly protective behaviour in respect to knowledge sharing.

[22] Talbot (2007, p. 11) refers to this institutionally imprinted behaviour as routinised action, analogous to the notion of organisational routines introduced by Nelson and Winter (1982).

Second, research into diversity discusses social categorisation on the basis of diversity traits, such as national culture, as a potential for conflict in groups or teams (Tajfel, 1982b). Accordingly, similarities and differences resulting from distinct cultural traits can be used as a basis for categorising oneself and others into groups, with ensuing categorisations into members of one's in-group versus those of one or several out-groups (van Knippenberg et al., 2004; Ely & Thomas, 2001). Following the logic of similarity and belonging (see section 4.2), individuals are assumed to favour their own in-group over out-groups. This can result in higher affection, trust and co-operation and thus greater in-group cohesion over out-groups, which, in turn, can obstruct inter-organisational knowledge sharing (Child & Rodrigues, 1996). One moderating variable for the strength and influence of social categories is the salience of differences, as defined by comparative fit, normative fit and cognitive accessibility (van Knippenberg et al., 2004). Comparative fit describes the discriminatory power of a given categorisation, i.e., the achieved level of within-group similarity and between-group differences. Normative fit comprises the extent to which a categorisation corresponds to an individual's frame of reference in respect to beliefs, expectations or stereotypes. Lastly, cognitive accessibility describes the ease with which the categorisation comes to mind and the readiness of the individual to use the categorisation. It is suggested that the more salient a trait, the more it contributes to group building and group thinking that interferes with inter-organisational team coherence (van Knippenberg et al., 2004; Tajfel, 1982a). National culture as a basis for social categorisation comes more easily to mind and becomes more salient the larger the cultural distance between the partners (Stahl et al., 2010; Zhang et al., 2008). However, it has also been suggested that the influence of social categorisation depends on its meaning in respect to the task at hand (van Knippenberg et al., 2004; Ely & Thomas, 2001). The less a given categorisation is related to the task, the lower its salience and thus excluding power. It can be suggested that other categorisations, e.g. based on different technical specialties (see section 4.4.5) that are directly linked to the task, might exert a more powerful criterion for exclusion.

While this argument suggests higher incidences of conflict with increasing distance between the national cultures of the partners, O'Grady and Lane (1996) as well as Lavie and Miller (2008) suggest a potential impedance when cultural differences are below a perceptual threshold. Lavie and Miller assume that 'as the understanding of the background of culturally relatively proximate foreign partners is considered straightforward, the firm may find it unexpectedly challenging to manage alliances with foreign partners because unwarranted assumptions of isomorphism can prevent recognition of critical national differences' (p. 10). In these constellations, critical differences might be underestimated, a phenomenon known as the 'psychic distance paradox' (O'Grady & Lane, 1996), according to which perceived similarities between the partners lead them to act on the expectation of similarity and to pay less attention to latent yet potentially critical institutional differences (Kogut & Singh, 1986).

Opposing the suggested benefits and costs of institutional distance between the partners argues in favour of an inverted U-shaped relationship between institutional distance and the outcomes of inter-organisational co-operation. That is, initial levels of institutional distance might be conducive to interactive learning and novelty generation, yielding a higher inventive potential than mere national co-operation projects; however, the novelty potential of high levels of institutional distance might be overshadowed by increasing problems in aligning the ability and the motivation of the participants to share knowledge. Likewise, Nooteboom (2009), drawing on his ideas of organisational cognitive focus and effective cognitive distance between organisations (see section 2.3), suggests the existence of an optimal level of psychological distance between culturally distant partners for the purpose of innovation, yielding optimal 'external economies of cognitive scope' (p. 131).

Taken together, inter-organisational co-operation between institutionally distant partners can be valuable in offering resources that are not available at home as well as external economies of cognitive scope due to a greater variety in views and capabilities. The expected recontextualisation of knowledge can itself contribute to novelty generation (see section 3.2). However, at the same time, institutional distance can be expected to increase the challenges in inter-organisational knowledge sharing, affecting both the ability and the motivation to share with and take knowledge from the partner. It can be assumed that the greater the 'cultural noise' in communication, the more likely it is that misunderstandings or misinterpretations will occur. Moreover, when tacit, causally ambiguous and emerging knowledge and capabilities where cause–effect relationships are poorly understood are at stake, communication problems may amplify. Furthermore, higher degrees of uncertainty due to a lower predictability of the partner's behaviour and a higher perception of relational risks might urge the partners to an overly protective behaviour, restricting knowledge flows between the partners. This might be reinforced when cultural differences are highly salient and favour group thinking, leading to exclusion mechanisms that eventually threaten the internal cohesion and functioning of the inter-organisational team. The discussion of potential distance–effects has further revealed a direct influence of institutional distance on the ability of partners to share and co-create knowledge. Thus, its effect is assumed to be stronger as compared to the geographic dimension, which has been suggested to be of a more indirect nature.

Small firms in particular might lack the power to shape home country institutions to their advantage and might be pushed to leverage resources in other institutional set-ups (Narula, 2003). On the other hand, smaller firms also often lack the means to enforce their rights, particularly on an international level, and the relative loss from relational hazards might be heavier for smaller firms. From International Business literature it is known that smaller firms tend to avoid high levels of cultural distance (Johanson & Vahlne, 1990, 1977; Johanson & Wiedersheim, 1975). These firms rather adopt a step-wise approach successively incurring larger cultural distance with higher levels of experience in doing international business. On the other hand, recent years have witnessed the rise of so-called 'born globals'. These firms are primarily found in high-technology or science-based industries and display a high degree of international activity right from or close to their inception, which at times also includes institutionally distant places and partners (e.g., Gassmann & Keupp, 2007a,b; Madsen & Servais, 1997; Oviatt & McDougall, 1997; Bloodgood, 1996; Oviatt, 1994).

Empirical Evidence

Whereas geographic distance has received scant attention in empirical studies, institutional distance, especially national cultural distance, has been more frequently addressed as a determinant of partnership formation, as well as the success of inter-organisational co-operation and knowledge sharing more specifically.

A first set of studies provides evidence on the impact of cultural distance on partner selection and the legal form of the inter-organisational venture (e.g., Mayrhofer, 2004; Coenen et al., 2003; Koschatzky, 2001; Steensma et al., 2000). In particular, existing evidence on inter-organisational co-operation in cross-border regions is insightful to demonstrate the impact of institutional distance on partnership formation, as well as its inter-relationship with geographical distance. For example, Koschatzky (2001) reports that the innovation and co-operation behaviour of SMEs located in a German–French border region differed strongly according to their institutional background. Despite geographic proximity, he observed low levels of cross-institutional co-operation. From a German perspective, Koschatzky ascribes this finding to (i) problems faced by German firms in understanding the French institutional structures and in approaching the organisations, particularly an inability to find the right tone, (ii) differences in mentality, (iii) higher bureaucracy and centralism in France, as well as (iv) a protected market in favour of national suppliers. Coenen et al. (2003) provide similar results in their investigation into the patterns of inter-organisational interaction within the Øresund biotechnology region. This region stretches across the national border between Denmark and Sweden – two countries with markedly different innovation systems. Similar to Koschatzky, Coenen et al. found few collaborative relationships between Danish and Swedish firms or research institutes. Both findings are indicative of a strong boundary that institutional distance exerts.

Another line of contributions turns to the effects of cultural distance on the evolution, performance and longevity of co-operative agreements (e.g., Hennart & Zeng, 2002; Pothukuchi et al., 2002; Barkema & Vermeulen, 1997; Park & Ungson, 1997; Barkema et al., 1996; Parkhe, 1991, 1993). These studies produce mixed results on the impact of cultural distance on inter-organisational co-operation. Hennart and Zeng (2002), for example, find that the longevity of Japanese–US joint ventures is lower than that of purely Japanese ones. Also Parkhe (1991, 1993) provides evidence that differences in partner nationality and culture negatively influence the success of inter-organisational co-operation, particularly the ability to benefit from knowledge spillovers. Barkema and Vermeulen (1997) examined the influence of differences in partners' national cultures on international alliance performance, drawing on Hofstede's (1980) dimensions of national culture; namely, individualism, power distance, uncertainty avoidance and masculinity. They found that partner differences in two of the dimensions – uncertainty avoidance and long-term orientation – had a strong negative relationship on the survival of the inter-organisational co-operation. By contrast, Pothukuchi et al. (2002) found in a sample of joint ventures by Indian firms that national cultural distance had a positive effect on the efficiency, competitiveness and satisfaction with the joint venture. They also based their measure of national cultural distance on the indicators provided by Hofstede. Likewise, investigating joint venture dissolution, Park and Ungson (1997) observed no negative impact of cultural distance. They reported that cross-border joint ventures with partners from culturally distant countries tended to last longer than those that included only national partners. In particular, US–Japanese joint ventures were less likely to dissolve than joint ventures between US firms.

There are comparatively few empirical studies addressing the impact of cultural distance on inter-organisational knowledge sharing (e.g., Pak et al., 2009; van Wijk et al., 2008; Lane et al., 2001; Simonin, 1999; Mowery et al., 1996). Mowery et al. (1996) found that there are higher levels of knowledge transfer in alliances of culturally similar compared to culturally distant partners. Similarly, Lane et al. (2001) established a positive relationship between cultural compatibility, as measured by perceived cultural misunderstandings and cultural differences, of international joint venture partners and the amount of learning from the partner. Also Pak et al. (2009) recently confirmed that cultural differences have a negative effect on cross-border learning within international joint ventures. Interesting results have also been revealed by Simonin (1999). In a sample of strategic alliances of US-based large and medium-sized firms, he found that cultural distance was a strong predictor of knowledge ambiguity, which in turn determined the difficulties in inter-organisational knowledge transfer. Thus, cultural differences can be assumed to amplify the problems of knowledge ambiguity, particularly in an inherent ambiguous process such as novelty generation. In a recent meta-analysis summarising current empirical evidence on antecedents and consequences of inter- and intra-organisational knowledge transfer, van Wijk et al. (2008) stated that overall evidence suggested that, as organisations are more culturally distant from each other, the amount of knowledge transferred between them decreases.
Moreover, Zhang et al. (2008) investigated the impact of in-group/out-group categorisations as defined by national cultural background and shared previous work experience on knowledge sharing. In a lab experiment including US and Chinese participants, they first found that US participants were generally more willing to share professional knowledge with others (in- as well as out-groups) than Chinese participants. Second, both US as well as Chinese participants were more likely to share professional information with members from the same in-group, including both shared cultural background and shared work experience, than with members from out-groups. However, the cultural belonging had less differentiating power compared to shared work experience. Thus, shared work experience can be interpreted as a moderator of the exclusionary effects of cultural social categorisation.

Recently, Stahl et al. (2010) published a meta-analysis summarising existing evidence on the impact of cultural diversity in teams. They found that cultural diversity fuels both creativity and conflict. Moreover, social integration within the team suffered from cultural diversity. However, Stahl et al. identified no significant effect of cultural diversity on the effectiveness of communication. By contrast, they discovered a higher level of satisfaction and motivation in culturally diverse teams. The net balance of these differentiated effects on the overall performance of the teams was not clear. These results are mirrored in recent qualitative studies of culturally diverse teams, which primarily point to heightened incidences of conflict in these teams (e.g., Bouncken & Winkler, 2010; Köppel, 2007).

Taken together, the empirical evidence so far points to the difficulties involved in sharing knowledge across institutional distance, while the potential benefits of cultural diversity have either received less attention or been based on verbal expressions from interviews, where the impression was gained that the potential for conflict somewhat outweighs the benefits.[23]

4.4.3 Organisational Distance

Definition and characterisation

The definition of organisational distance likewise broaches the 'rules of the game' (see section 4.4.2), although on an organisational as compared to the national or subnational level of institutional distance. Specifically, organisational proximity is defined as

> *'the extent to which organisations have adopted 'similar mental maps, organisational routines, corporate culture, and management style'* (Wuyts et al., 2005, p. 291).[24]

[23] What must be acknowledged in this summary of empirical evidence is the fact that few of the studies, with the notable exception of the contributions by Bouncken and Winkler (2010) and Köppel (2007), have adopted the perspective of German firms. They mostly focus on US firms and recently increasingly on Indian (Pothukuchi et al., 2002) and Chinese (Dong & Glaister, 2007) ones. According to Hofstede's classification, Germany upholds a middle position, which supports interactions with different foreign cultures (Wagner, 1998). Accordingly, the results in regard to the effects of institutional distance might differ. Moreover, they mostly investigated into international joint ventures or alliances which differ in central characteristics, particularly in respect to duration, from inter-organisational projects (Knoben & Gössling, 2009).

[24] The logic underpinning organisational distance deviates here from Boschma's (2005a) initial interpretation of organisational proximity as 'the extent to which relations are shared in an organisational arrangement, either within or between organisations' (p. 65). For him, organisational proximity ranges from autonomy in loosely coupled organisations to

Organisational distance as the inverse of organisational proximity describes the extent of dissimilarity in mental maps, organisational routines, corporate culture and management style.

According to the definition, the most fundamental level of dissimilarity between two organisations is found within their characteristic 'mental maps' which relates to the notion of organisational 'cognitive focus' (Nooteboom, 2009, see section 2.3). Shared mental maps or cognitive foci shape the 'deep-level cognitive structures' as proposed by Nooteboom (2009) that define the most elementary self-perception of an organisation; its basic visions, goals, logics, principles and convictions. These lead to shared perceptions of its members in regard to the business the organisation operates in as well as its core mission and competencies. This basic self-perception is mirrored in the organisation's culture, understood as 'a common set of rules, a shared way of thinking and ethical behavioural code, together with the beliefs, experiences, precedents and procedures that provide values and build up method and context as well as the language for the organisational activities' (Morroni, 2006, p. 141). According to Morroni, organisational culture functions as a behavioural guide, which facilitates co-ordination, helps to communicate by providing a common language, creates a feeling of belonging, enhances mutual trust through appropriate expectations on the behaviour of the members of the organisation, maintains cohesion, operates as a motivator and represents a tool to control individual behaviours.

The two remaining elements that characterise organisational distance relate to what Nooteboom (2009) calls 'surface regulations'.[25] An organisation's management style is manifest in its structure, its hierarchical set-up, as well as its patterns and lines of communication and authority. Lastly, organisational routines are addressed in the definition. The notion of organisational routines was forwarded by Nelson and Winter (1982). For them, a routine 'may refer to repetitive pattern of activity in an entire organisation, to an individual skill, or, as an adjective, to the smooth unevent-

hierarchical control in intra-firm networks. As this thesis focuses on inter-organisational co-operation, an alternative interpretation as forwarded by Broekel and Boschma (2009) in a later contribution is adopted, where the authors define organisational proximity as the degree to which organisations 'have similar routines and incentive mechanisms' (p. 5).

[25] When depicting deep-level structures as the genotype of an organisation, these surface regulations correspond to the phenotype, i.e., the expressed form of an organisation's fundamental characteristics. However, it is questionable as to whether routines are surface regulations, as these are currently perceived as the central carriers of knowledge within a firm that safeguard continuity even when individual people leave the organisation (Nelson & Winter, 1982).

ful effectiveness of such an organisational or individual performance' (p. 97). Thus, routines are patterns of actions or interactions that are characteristic and essential for the functioning of an organisation. They represent the ' "locus" of operational knowledge in an organisation' (p. 104) and have often stepped back into 'subsidiary awareness' (p. 78) of its members. That is, the performers of a routine are often not consciously aware of its existence or its components which often constitute collective patterns of actions as found in communities of practice (Amin & Roberts, 2008; Amin & Cohendet, 2004; Gherardi & Nicolini, 2002; Brown & Duguid, 1991; Lave & Wenger, 1991; Wenger, 1998, see section 3.2).

Together, these elements are key constituents of a firm; they shape its characteristics and actions, define its boundary and distinguish its identity from other organisations. What distinguishes the organisational dimension from the former dimensions is that the points of reference are the individual organisations involved in the co-operation project. Hence, organisational distance is defined at the meso, or collective organisational, level.

Expected Impact on Inter-Organisational Co-operation in R&D

To leverage external resources, knowledge and capabilities that are tied to other organisations, firms need to reach beyond their organisational boundaries. Particularly in regard to the generation of novelty, the combination of resources and capabilities across organisations seems an important lever to yield a requisite level of variety that is supportive to realise new combinations. In this vein, Nooteboom (2009) suggests that new impetus and 'external cognitive scope' (p. 131) from inter-organisational co-operation are conducive to invention and innovation and serve to re-calibrate and adapt an organisation's trajectory.

The crux is, however, that, while inter-organisational co-operation is seen as a valuable means to leverage and combine distinct resources, particularly knowledge, the key organisational advantage is currently seen as resting upon an organisation's capacity to effectively and efficiently share and create knowledge and to exclude others from its use (Grant, 1996; Kogut & Zander, 1992). A shared mental map, organisational culture, management style and organisational routines together create the basis for effective and efficient knowledge sharing within an organisation.[26] They raise tacitness, causal ambiguity and social complexity of a firm's competitive advantage that constitute central exclusion mechanisms protecting the firm from external imitation. It follows that this organisational advantage likewise presents a central barrier in deliberate processes of knowledge sharing with external partners.

Thus, considering the **ability** to share knowledge between the partners, Wuyts et al. (2005) suggest that different mental models create different 'visions of the world' (p. 292) which impede mutual understanding. Similarly, Tushman (1977) addresses communication problems across organisational boundaries due to individually and collectively generated knowledge, language and codes. He suggests that 'these inherent conceptual and linguistic differences act as a communication impedance or as a communication boundary hindering the free flow of information. The greater the differentiation, the greater the communication impedance' (p. 591). It has further been suggested that inconsistencies between the partners' 'normal ways of "doing business" ' (Cummings, 2003, p. 20) can significantly affect knowledge-sharing processes and outcomes. Cummings cites Gersick and Hackman (1990), who found that group interaction unfolds more easily and instantaneously in a well co-ordinated form if (a) group members' scripts are similar to one another's and (b) members' definition of the situation are similar. Scripts are defined as 'a structure that describes appropriate sequences of events in a particular context, ... a predetermined, stereotyped sequence of actions that defines a well-known situation' (Schank & Abelson 1977, p. 41, taken from Nelson & Winter 1982, p. 79). They prescribe appropriate responses to stimuli and thus support the co-ordination and integration of activities and capabilities. This assertion is backed by Rocco et al. (2000), who observe that different sites within one multinational firm experienced significant communication problems due to different styles in communication protocols and documentation that inhibited the smooth exchange, interpretation and internalisation of data. In regard to inter-organisational co-operation, Lane and Lubatkin (1998) assume that knowledge sharing is essentially supported if the partners resort to similar knowledge-processing systems. Otherwise, problems at the organisational interfaces are expected.

[26] Kogut and Zander (1992) suggest that organisations possess 'a set of higher-order organizing principles [that] act as mechanisms by which to codify technologies into a language accessible to a wider circle of individuals' (p. 389).

Correspondingly, the communication model developed by Haworth and Savage (1989), that has been introduced in section 4.4.2, can also be applied to derive insights into the impact of organisational distance on inter-organisational communication. This time, the different organisational characteristics, as defined by the respective organisational mental maps, cultures, management styles and routines, shape the 'phenomenal fields' of the sender and the receiver of a message. The greater the overlap in the organisational phenomenal fields, the easier communication across organisational boundaries is considered to be. Thus, the conclusion can be drawn that organisational distance, analogous to institutional distance, is a direct predictor of the ability of the partners to share, integrate and combine each other's knowledge.

The analogy to institutional distance can be continued: it has been suggested in the previous section that national cultures differ in their general explicit/implicit ratios used in communication as well as their preparedness to share knowledge. Similarly, it has been reported that firms differ in their styles and mentalities toward knowledge sharing. There are significant differences reported in the way that organisations manage their knowledge, from a laissez-faire approach where knowledge is primarily stored in the heads of employees to highly sophisticated storage and retrieval systems backed by electronic solutions where knowledge is constantly expressed and codified (Leidner et al. 2008, Nooteboom 2004).[27] Knowledge stored in manuals is much more easily processed and handed over to external partners. Also in regard to mentalities toward knowledge sharing, differences have been reported ranging from more egocentric to more open communication styles. This has been further linked to the prevailing reward structure of the firm favouring either individual or group achievements (Zhang et al., 2008). It has been observed that in situations where

[27] Particularly within SMEs, hierarchical and operational structures are often said to be less pronounced, as a threshold level of employees to incorporate a sophisticated division of labour is not reached (Arnold & Thuriaux, 1997). Consequently, co-ordination and communication tends to be rather informal and personal. Moreover, Nooteboom (2004b, 1999) surmises that small organisations are characterised by a less systematic knowledge-management process, with large parts of knowledge carried by central employees, and thus highly tacit. Nooteboom (2009) explains that 'a difference in culture between large and small firms lies in the fact that with a more extensive division of labour, with co-ordination between greater numbers of people across possibly distance organisational units, knowledge and rules need to be codified to a greater extent than in small firms, where co-ordination can take place by direct supervision' (p. 115). This can eventually hamper the knowledge-sharing process when small firms for which these characteristics apply are involved in inter-organisational co-operation.

group achievements are incentivised and rewarded, employees adopt a more open approach toward knowledge sharing. Furthermore, they are accustomed to team work that in turn supports the functioning of inter-organisational teams. Similarly, Easterby-Smith et al. (2008c) suggest that the hierarchical structure of a firm seems to affect both intra- and inter-firm information flows. The more distant the co-operation partners are in their structure, operations, culture and communication styles, the less they will be prepared for inter-organisational knowledge sharing.

These frictions are thought to emit on the **motivation** of the partners to share knowledge. In particular trust, social identity and interest have been identified as central motivational drivers to knowledge sharing (section 3.3). Likewise, the literature on co-operation stresses soft factors such as similarities in organisational culture or similar social identities as factors that are conducive to trust building (Borgatti et al., 2009; van den Hooff & Schipper, 2009; Child et al., 2005; Child & Rodrigues, 1996). In the previous discussion, comparable scripts were suggested to trigger comparable responses to stimuli that supports knowledge sharing and in parallel renders the behaviour of the partner more predictable. Thus, in a situation of not fully specifiable contracts as characteristic for R&D, similar cognitive frames, or scripts, may lead to comparable reactions to unforeseen circumstances that are anticipated and comprehended by the partner. This again increases trust in the partner and the commitment to the co-operation.

Moreover, the notion of social categorisation has been introduced in section 4.4.2. It has been suggested that on the basis of perceived differences, groups tend to be created, differentiating between ‘us’ (in-group) and ‘other’ (out-group). It is particularly the salience of these distinctive features in terms of comparative fit, normative fit and cognitive accessibility that defines the discriminatory power and thus also the power of attraction of a specific grouping. Groupings based on the organisational belonging are evident; even more when they are pre-established, such as the categorisation into firm versus university as well as small firm versus large firm. The more easily these groupings come to mind, the higher the expected effects thereof, such as a lack of cohesion, dislike or foreclosure.

Further, van Knippenberg et al. (2004) suggest that social categorisation matters particularly when it is fueled by a perceived threat from the other. This is most markedly expressed in the discussion about the ‘not invented here syndrome’ (NIH) (Chesbrough, 2006; Katz & Allen, 1982). This syndrome describes the ‘internal resistance to external innovations and technologies' (Chesbrough, 2006, p. 23). Chesbrough (2006) continues to oppose this phenomenon to a 'not sold here' (p. 32) syndrome, describing a limited willingness of organisational members to make their own knowledge accessible to people outside the organisation. Both types of resistance can affect the motivation to uptake and disseminate knowledge between the partners, and hence effective and efficient knowledge sharing. As these differences are closer related to the task as compared to institutional distance, it can be suggested that they exert a stronger discriminating effect than classifications based on institutional affiliation.

Taken together, high levels of organisational distance can impede knowledge sharing in inter-organisational co-operation projects in various ways. Both 'deep-level cognitive structure' and 'surface regulation' provide the basis for effective and efficient knowledge sharing within organisations. However, in inter-organisational knowledge sharing, a lack of shared basic logics can lead to deviant behaviour and expectations in regard to the goals of the co-operation project, mutual contributions, roles and procedures. Moreover, organisations differ in their openness toward knowledge sharing and their general knowledge-sharing practices, as well as their codes and meanings that underpin communication, which tend to be deeply anchored in organisational routines or communities of practice. Incompatible routines or scripts can also hamper inter-organisational knowledge sharing. In addition, increasing levels of organisational distance can lead to a lack of shared identity and trust, which in turn advocates group thinking and the non-acceptance of outside knowledge (NIH) or the resistance to sharing knowledge with outsiders (NSH). Together, this suggests a rather negative effect of organisational distance in regard to both, knowledge-sharing ability as well as motivation.

Empirical Evidence

Although less research exists on the influence of organisational compared to institutional differences, the current literature provides some evidence on the impact of organisational distance, particularly differences in organisational culture, on the formation as well as success of inter-organisational co-operation.

Social network studies stress that firms tend to display a 'preferential attachment', i.e., a preference for or attraction toward organisations that are similar along socially significant dimensions (Borgatti et al., 2009; Lamburgey et al., 2008; Podolny, 2001; Darr & Kurtzberg, 2000; Podolny, 1994; Gulati & Gargiulo, 1999). Kim and Higgins (2007) forward evidence on the influence that homophily exerts on partner selection, such that firms occupying similar positions in their market's social structure inherit similar obligations and expectations that draw them toward each other. Investigating the role of organisational distance for alliance formation in the ICT industry, Wuyts et al. (2005) found an inverted U-shaped relationship between organisational distance and the likelihood of any two organisations forming an alliance. This suggests that a certain level of organisational distance is sought in inter-organisational co-operation, particularly in regard to the realisation of strategic goals, which was the prime focus of their study.

In regard to the effects of organisational distance within the co-operation, particularly on knowledge sharing and learning, Lane and Lubatkin (1998) showed in a sample of co-operative agreements between pharmaceutical and biotechnology firms that similar organisational structures for assimilating new knowledge, which they proxied via the degree of formalisation and decision centralisation, can support inter-organisational learning between the partners. However, the significant levels and effect sizes for this factor were rather weak. Simonin (1999) finds that organisational distance in terms of differing business practices, operational mechanisms, organisational culture and management styles, contribute to a higher degree of perceived knowledge ambiguity within alliances. Knowledge ambiguity is in turn negatively related to knowledge transfer. Ermisch (2007) probes the correlation between organisational differences in various dimensions and co-operation success and corroborates the importance of partner similarity for successful co-operation.

There are also a number of studies that investigate the role of different organisational cultures – particularly in relation to national culture – for the success of inter-organisational co-operation (e.g., Pothukuchi et al., 2002; Inkpen, 1998; Park & Ungson, 1997). These studies mostly agree that comparable organisational cultures between the partners are an important prerequisite for successful co-operation, and are even more decisive than compatible national cultures. In their study of international joint ventures from the perspective of Indian firms, Pothukuchi et al. (2002) provide detailed analysis of the perceived effects of organisational distance in regard to different performance measures. They base their measure of organisational cultural distance on a composite indicator, aggregating the perceptual evaluation of firms in regard to six different indicators.[28] From this, they find that organisational cultural distance has a negative effect on all three performance measures of efficiency, competitiveness and satisfaction with the joint venture. Particular negative effects are found in regard to satisfaction, followed by competitiveness. They conclude that organisational cultural differences primarily exert a negative psychological effect on the employees. In contrast, they established a positive effect of national cultural distance in all performance dimensions (see section 4.4.2). Also Park and Ungson (1997), in their investigation of success factors of international joint ventures, conclude that differences in organisational culture can lead to friction between the firms, whereas national cultural distance can be conducive to the longevity of co-operation. They observe that differences in organisational culture eventually lead to the dissolution of joint ventures as partners are forced to divert attention and energy to developing interaction routines aimed at overcoming these differences. Also Inkpen (1998) establishes the variable 'alignment of managerial culture between the partners as an important precondition for learning to take place in alliances.

Another area of investigation that provides insights into the effects of organisational differences is research on the the multinational firm where knowledge, capabilities and practices are transferred from one site to another. For example, van den Hooff and Schipper (2009) empirically demonstrate how social identity among actors within firms supports knowledge sharing. Rocco et al. (2000), as cited above, also observed that different sites within one multinational firm experienced communication problems due to different operating styles that inhibited the smooth exchange, interpretation and internalisation of data. It can be concluded that similar problems occur when two separate organisations engage in co-operation.

Overall, the existing evidences suggests that organisational proximity between the partners supports knowledge sharing, contributes to mutual satisfaction and increases the effectiveness and the survival of inter-organisational co-operation, whereas distance tends to have a negative impact.

[28] The indicators used by Pothukuchi et al. (2002) are: the firms' orientation in regard to process versus result; employee versus job; parochial versus professional; open versus closed; loose versus tight control and normative versus pragmative.

4.4.4 Strategic Distance

Definition and Characterisation

Strategic distance is defined here as

> *The (actual or perceived) absence of a direct or indirect tie to a current or potential future competitor.*

It has been witnessed recently that competitors in the market place simultaneously collaborate on the generation and development of new knowledge, products or technologies (Loebbecke et al., 1999; Brandenburger & Nalebuff, 1996). To capture this ambivalence, Brandenburger and Nalebuff (1996) coined the term 'co-opetion', a hybrid construct of 'competition' and 'co-operation'.

As stressed in the definition, competitive links between the partners can already exist at the time the co-operation is formed; they can also arise as a result of the co-operation project. In this case, a future state of rivalry might result from the sharing and co-development of knowledge and competences, accompanied by a convergence in the knowledge and capabilities of the partner organisations. Furthermore, in times of increasingly dense networks, strategic or competitive proximity is not only founded upon a direct link to a competitor, but can also be found at the second or third degree in the form of an indirect tie to a (current or future) competitor (Nooteboom, 2009). In this case, the co-operation partner also engages in co-operative projects with (potential) competitors of the focal firm. As co-operation is a mutual process, the latter risk can also apply for the focal firm having ties to competitors of the partner (Nooteboom, 1999).

Similar to the organisational dimension, the strategic dimension is positioned on a meso or collective level of the respective organisations.

Expected Impact on Inter-Organisational Co-operation in R&D

In recent years, a number of cases have been reported where competitors also collaborate in the generation of new or enhanced knowledge, products, processes or services

(Loebbecke et al., 1999; Brandenburger & Nalebuff, 1996). However, sharing strategic knowledge with rivals fundamentally contradicts basic competitive rationales: competition is essentially about being comparatively better than competitors. It follows that the net contribution of the co-operation should contribute to an increase in the focal firm's knowledge and capability base and not to the partner's. Analogously, Cohen and Levinthal (1990) state that 'knowledge is assumed to be useful to the firm in that increments to a firm's own knowledge increase the firm's profits while increments to rivals' knowledge diminish them' (p. 141). This ambivalence in the roles of the partners vis-à-vis each other in a co-opetitive relationship can create tensions that affect the course and outcomes of an inter-organisational co-operation project. Thus, primarily **motivational** issues to share knowledge within the co-operation project are addressed in this dimension.

On the one hand, it has been suggested that learning is even greater in constellations of strategic proximity than in non-competitive co-operative relationships as the aspirations to achieve results as well as the pressure and tension to learn from the other and reap benefits from the co-operation project rise (Luo, 2007; Child et al., 2005; Quintana-García & Benavides-Velasco, 2004; Baum et al., 2000).

On the other hand, this pressure and tension can result in motivational and behavioural imbalances. The main risks in constellations of current or future rivalry within inter-organisational co-operation is that the partner 'out-learns' (Hamel, 1991, p. 84) the focal firm; this can lead to a redistribution of knowledge and profits (Hamel, 1991). Hence, co-operation can culminate in a 'learning race' where the partners try to extract as much knowledge as possible from the partner while simultaneously revealing as little as possible of their own knowledge and capabilities (Easterby-Smith et al., 2008c; Brossard & Vicente, 2007; Narula & Santangelo, 2007; Lubatkin et al., 2001; Baum et al., 2000; Oxley & Sampson, 2004; Khanna et al., 1998). In addition, as co-operation requires an opening of the organisation toward the partner, the partner may also gain access to detailed information about other business areas, on-going or planned projects or other partners, suppliers and customers. This might be a surplus gain next to the direct achievements within the co-operation that can constitute an important threat in a competitive situation (Specht et al., 2002). Thus, Dyer and Singh (1998) assume that 'the willingness of firms to combine complementary strategic resources may also hinge upon credible assurances that the trading partner will not attempt to duplicate those same resources, thereby becoming a future competitor' (p. 670). However, it can be suggested that as the gains from opportunistic behaviour are greater, the incentive to refrain from acting opportunistically is lower. Therefore, it can be expected that trust, particularly behavioural trust, suffers from increasing levels of strategic proximity (Larsson et al. 1994). Consequently, Lubatkin et al. (2001) hold that ‘a collaborative learning environment can quickly turn into knowledge predation through withholding, or misrepresentation of information and distrust between the partners’ (p. 1359).

Moreover, with invention and innovation becoming increasingly open processes involving a multiplicity of external actors, the risk increases that confidential information leaks unintentionally to third parties who might be or become competitors of the focal firm. Both constellations – direct or indirect competitive threats – can lead to knowledge withholding, misrepresentations or distrust.

This knowledge-sharing dilemma has been systematically analysed and formalised by Schrader (1990) in a game-theoretic model of information transfer decisions between organisations (figure 4.4). In his version of the ‘prisoner’s dilemma’, Schrader analyses a situation with two organisations which each holds a piece of information valuable to the other. Both pieces of information are of the same base value r. The exclusive possession of the information yields an extra value of Δr. Its sharing would then lead to a loss of Δr. The combination of the two pieces of information through an exchange of information between the partners could lead to an extra surplus of double the value (2r), under the condition that 2r > r+Δr. The crux is that if one party does not transfer, the other loses his value of the exclusive possession of the information without being refunded, leaving him at the base value r, while the other party gains double the value plus the value of the exclusive possession of his initial stock of information (2r+Δr). Not knowing which strategy the partner is going to choose, whether he reveals his information or not, the dominant strategy for both partners would be not to transfer information. However, considerable synergies between the parties would be lost.

This presentation of the classical prisoner’s dilemma explains simultaneously why rivals have an incentive to co-operate, as well as what might hold them back from being the prime mover in revealing sensitive information to the other.

It is known from experiment that multi-period games reduce the probability of defection due to expectations of future interaction (Axelrod, 1984). Thus, when ac-

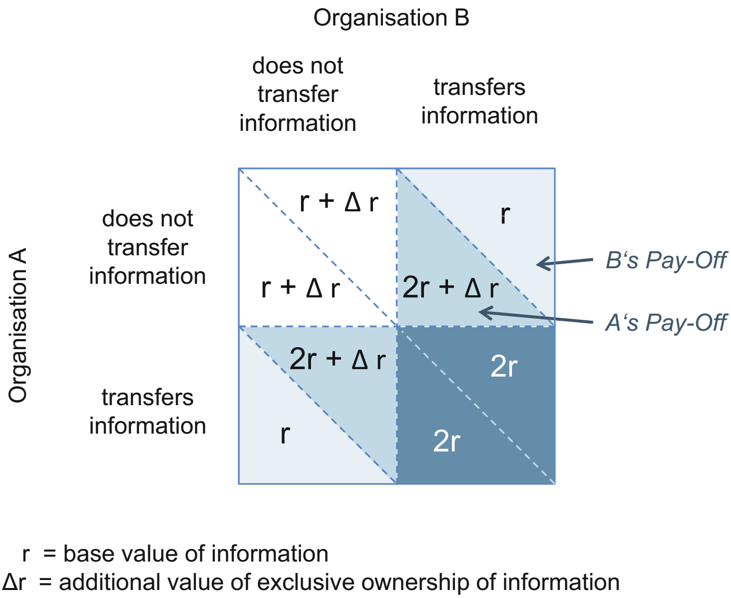

Figure 4.4: Inter-organisational Information Transfer Dilemma (adapted from Schrader 1990, p. 27)

tors are likely to repeatedly engage in interactions, the future will cast a shadow over the present, and the partners are likely to base the co-operation on reciprocity. Also Schrader concludes that information transfer only takes place based on a long-term perspective and high levels of trust between the partners. However, co-operation projects are typically of a limited duration. According to the model, the resultant response would then be not to share any knowledge with the partner. Yet the model also neglects other, primarily relational, factors that inhibit defection, such as trust, affection, personality or potential reputation losses in the wider business or research community (Gulati, 1995a,b, see section 4.4.6).

Moreover, the two alternatives – ‘actor transfers information’ and ‘actor does not transfer information’ – are only two extreme positions. In knowledge-sharing processes, there are various possibilities situated in between the two extremes, such as the possibility to cautiously reveal some parts of information while holding back or distorting others, or else explicitly delineating the object of co-operation contractually. This might not be recognised by the partner, but could affect the efficiency and effectiveness of knowledge sharing (Lubatkin et al., 2001; Loebbecke et al., 1999). Together, this suggests a protective and selective information policy on the part of the partners, whereby the partners are particularly concerned about keeping important knowledge tacit (Child et al., 2005).

It can be assumed that, depending on the degree of strategic distance and the perception a firm has of the relational risks, its degree of protectiveness will vary, potentially impeding an open information transfer. As Loebbecke et al. (1999) stress, the nature of co-opetition raises the issue of 'what to share with whom, when, and under what conditions paramount in a firm's effort to achieve sustainable competitive advantage' (p. 218). In this sense, Loebbecke et al. (1999) call for a conscious management and regulation of knowledge-sharing processes. It appears reasonable that 'firms that perceive themselves to be engaging in a learning race will probably behave differently in the process of transferring or acquiring knowledge than firms that do not.' (Easterby-Smith et al., 2008c, p. 682). Thus, in situations of current or potential future competition, the partners will be reluctant (or are even advised not) to disclose too much information. Consequently, this can lead to increased disparities between information needs and information offers and inefficiencies in knowledge sharing within the co-operation project. Any attempts to guard and selectively share knowledge can harm the efficiency and effectiveness of knowledge sharing in a co-operative project. This dilemma is also summarised by Oxley & Sampson (2004), who state that 'participants in research and development alliances face a difficult challenge: how to maintain sufficiently open knowledge exchange to achieve alliance objectives while controlling knowledge flows to avoid unintended leakage of valuable technology.' (p. 723).

It has been argued that the firms might be eager to learn from each other, but reluctant to disclose their own information. However, it might also be the case that those involved in the co-operation might be reluctant to learn from a competitor. Hence, the receptivity for the knowledge and specific capabilities of the partner - not just the willingness to share knowledge - might likewise suffer. This corresponds to the motivational drawbacks of the 'not invented here' and the 'not sold here' syndromes as outlined in section 5.3.3. Similarly, Lubatkin et al. (2001) assume that most actors will initially hold a higher psychological bond to their own organisation's goals, values and organisational style than to the alliance. On the other hand, it has been evidenced that researchers often pursue their visions with those who support their ideas independent of organisational identity or rivalry. Hence, competitive threats are often valued less and are only anticipated if initial trust and expected reciprocity have obviously been violated by the partner (Schrader, 1991)

Taken together, the need to open up the organisation to another one is thought to be problematic in constellations of strategic proximity between the partners. Although the inducement to learn and reap benefits from the co-operation project might be high, the team members will face a tension between openness to the partner and the need to protect key knowledge. The risk of being out-learned can lead to an imbalance in the knowledge sharing process. Each firm might be highly motivated to access and uptake the knowledge of the other, but less motivated to share own knowledge. In a competitive relationship, the threshold level for defection might be lower, and as a response, the levels of distrust and protective behaviour higher. This can be particularly notorious in R&D, as inter-organisational co-operation in R&D is based on incomplete contracts in which contributions and outputs, as well as the rights to use the output, may not be well specifiable (Baum et al., 2000).

This discussion showed that strategic distance differs from the other dimensions of distance as the direction of the effect is inverted, where 'less distance' is not necessarily better and 'more distance' not necessarily harmful.

Empirical Evidence

Using his game-theoretic model, Schrader (1991) investigated the impact of strategic proximity in informal information exchanges between firms. In a sample of US firms from the specialty steel and mini mill industry, he confirmed that the likelihood of information transfer significantly decreases if the firms are direct competitors. Yet, it rose again when the information did not relate to any highly competitive domains. In addition, Schrader provided evidence on potential indirect threats of information diffusion to competitors. However, in a series of interviews, he also experienced the existence of an informal rule that 'information that one firm receives from another firm should not be given to a third firm' (p. 156).

Turning to co-opetitive relationships, the effect of competitors having to share knowledge in inter-organisational co-operation is rare (Quintana-García & Benavides-Velasco, 2004; Baum et al., 2000). In a sample of co-operative agreements of European biotechnology firms, Quintana-García & Benavides-Velasco (2004) found support for their hypothesis that co-opetitive relationships may increase the capacity of firms to innovate. That is, co-operation with direct competitors contributed positively to the firms' subsequent diversification in terms of the development of new product lines as well as their technological diversity. Baum et al. (2000) analysed the effects of the characteristics of Canadian start-up biotechnology firms' networks on their early success. Defining rivalry as having a high overlap in the partners' market domains, they found support for the hypothesis that a start-up's initial performance is weakened by alliances with potential rivals at the time of their foundation. In this case, the firms exhibited significantly slower rates of patenting and revenue growth, as well as growth in R&D spending. They concluded that 'rivalries are fiercest and most damaging in collaborations among potential rivals' (p. 271).

Addressing the risk of indirect knowledge spillovers to competitors through a shared supply network, Dyer and Hatch (2006) proved from the example of Toyota that the benefits of sharing knowledge with the supplier network largely outweigh the eventual costs of indirect knowledge diffusion. They observed barriers in the transfer of inter-organisational routines to other partner constellations, inhibiting indirect knowledge drain. However, Dyer and Hatch investigated a very complex setting, including a whole network of suppliers, sharing bundles of inter-organisational routines over a long period of time.

Other studies on success factors for inter- as well as intra-organisational co-operation and knowledge sharing included the variable 'partner protectiveness' into their models. Although the link between co-opetition and protectiveness of the partner is up for discussion, these studies provide interesting results. Nielsen (2007) found in a sample of international strategic alliances that high perceptions of the partner's protectiveness had a significantly negative effect on the relationship between the partners, the alliance's financial performance, as well as the amount of learning derived from it. Simonin (1999) investigated the determinants and impact of ambiguity in the process of knowledge sharing in strategic alliances from different sectors. While ambiguity of knowledge is related negatively to the degree of knowledge transfer, the perceived level of partner protectiveness was no significant predictor of knowledge ambiguity. Investigating the impact of organisational culture on knowledge sharing within firms, van den Hooff and Schipper (2009) provided evidence that a cultural environment marked by competitiveness will impede knowledge sharing.

Likewise, Husted and Michaelova (2002) investigated firms' internal hostilities toward knowledge sharing. One reason for not being willing to share knowledge with other organisational members was through fear of a potential loss in value, bargaining power, and protection of (individual) competitive advantage. These concerns can also be expected in inter-organisational settings of knowledge sharing.

Finally, Chesbrough (2006) described a case where too much openness vis-à-vis the partner led to the eventual failure of a start-up firm. In the outlined case, a small technology-based firm exposed its new technology to a potential partner who was at that time envisaged as a potential customer of the resulting product. However, the established firm, a large incumbent firm, managed to out-learn the focal firm and established its own rival line of products, successively squeezing the initial inventor out of the business.

Taken together, empirical studies on the role of rivalry within co-operation are rare. Those that have addressed the effects of co-opetition, or the impact of protectiveness in co-operation as a potential consequence of co-opetition, provided mixed results in regard to the effect of rivalry within a co-operative relationship.

4.4.5 Technological Distance

Definition and Characterisation

Following Boschma (2005), technological proximity[29] is understood as

> '*... people sharing the same knowledge base and expertise'* (p. 63).

[29] Boschma (2005a) uses the term 'cognitive proximity' in reference to Nooteboom (2000, see section 2.3). However, Nooteboom generally adopts a broad understanding of cognition, 'going beyond rational inference, know-what and know-how, to include perception, interpretation, value judgments, morality, emotions and feelings' (Nooteboom, 2009, p. 1). However, in his empirical studies, Nooteboom often reduces the scope of cognitive distance to 'technological cognitive distance' (Wuyts et al. 2005, p. 282; Nooteboom et al. 2006, p. 5). This narrow understanding is also what Boschma (2005a) refers to with the expression 'cognitive distance'. The narrower concept of technological distance is used here to refer to differences in scientific knowledge and technical skills between the partners.

Technological distance is then a construct of how much the knowledge bases and bodies of expertise differ between the partners. In regard to collaborative R&D, the overlap comprises mainly the domains of scientific knowledge and technical skills of the partners.

Lane and Lubatkin (1998) offer an important amendment to the discussion of knowledge base relatedness by distinguishing 'basic knowledge' from 'specialized knowledge' (p. 464). Basic knowledge refers to a most general understanding of the contents, cause–and–effect relationships, traditions and techniques upon which a scientific discipline is based. According to the taxonomy of knowledge types proposed by Johnson et al. (2002) that was introduced in section 1.5, basic knowledge corresponds to 'know-what' and 'know-why'; i.e., knowledge about facts or knowledge about principles and laws of nature. Specialised knowledge by contrast includes the tacit competencies and technical skills that each partner holds. Referring to Johnson et al. (2002), specialised knowledge can best be characterised as 'know-how'; i.e., the ability to do certain things. People and organisations can possess similar basic knowledge bases, but may have adopted divergent technological trajectories and accumulated expertise in different domains of specialised knowledge. Thus, by distinguishing basic knowledge from specialised knowledge, Lane and Lubatkin (1998) underscore that the quest for complementary knowledge does not automatically imply that the partners differ fundamentally in their (basic) knowledge bases. Furthermore, besides sharing basic knowledge or having accumulated specialised expertise in certain methods and techniques, partners may share relevant knowledge and capabilities in relation to applications, products or markets (Brossard & Vicente, 2007). Finally, some overlap in the knowledge bases of the partners can stem from earlier practical experience with the knowledge base and expertise of the other independently of the idiosyncratic basic and specific knowledge repertoires (Cohen & Levinthal, 1990). Taken together, technological proximity (distance) is founded upon similarities (differences) in the respective 'knowledge endowment composition[s]' (Lanza, 2005, p. 26) of the partners. These knowledge endowment compositions can be made up of various elements from market and application knowledge, specialised (technical) knowledge, basic disciplinary or experience-based knowledge.

Another important element of the definition of technological distance is the reference to 'people'. As knowledge or 'knowing' (Amin & Cohendet, 2004) resides within the heads and actions of people, the analysis now turns to the level of the individuals who are involved in the co-operation project (micro, or individual level).

However, knowledge also resides within patterns of interaction among people in an organisation and can be located at a meso, or collective level. Referring to the concept of absorptive capacity, this has also been stressed by Cohen and Levinthal (1990) stating that 'an organization's absorptive capacity will depend on the absorptive capacities of its individual members' (p. 131). Nevertheless, a 'firm's absorptive capacity is not, however, simply the sum of the absorptive capacities of its employees' (p. 131). It 'is not resident in any single individual but depends on the links across a mosaic of individual capabilities' (p. 133).

Expected Impact on Inter-organisational Co-operation in R&D

In essence, a prime rationale for co-operation is that firms differ in their resource endowments and capabilities (Das & Teng, 2000; Eisenhardt & Schoonhoven, 1996). Thus, co-operation by definition is sought to access resource differences or 'external economies of cognitive scope' (Nooteboom, 2009, p.131). In regard to innovation, this heterogeneity in resources and capabilities can be regarded as conditional to realise novel combinations, an important source of innovation in the tradition of Schumpeter (1997). It is assumed that the more diverse the knowledge bases brought together in inter-organisational processes of R&D, the higher the inventive potential and the likelihood of breakthrough innovations (Nooteboom, 2009; Lubatkin et al., 2001; Cohen & Levinthal, 1990).

On the other hand, these differences also define the challenges the partners are faced with in regard to their **ability** to share knowledge. The argument commonly found in contemporary literature builds on insights from learning and cognitive theory. In this literature, it is assumed that the learning of new things is strongly conditioned by what is already known and subject to established frames of cognition and sense-making (Amin & Cohendet, 2004; Cohen & Levinthal, 1990; Inkpen, 1998). Learning is seen as a cumulative and path-dependent process: to learn something new, one utilises one's existing knowledge to enable interpretation and attach meaning (Cohen & Levinthal, 1990; Picot et al., 2003; Justus, 1999; Inkpen, 1998).[30] Drawing on these insights, Cohen and Levinthal (1990) refer to the existence of prior levels of related knowledge as a determinant of absorptive capacity. In their words,

[30] In section 3.2, the inseparability of expressed and tacit knowledge as well as the contextuality of sense-making of incoming information have been discussed. Hence, existing (tacit) knowledge provides the basis to frame new information and shapes learning processes.

'prior knowledge permits the assimilation and exploitation of new knowledge. Some portion of that prior knowledge should be very closely related to the new knowledge to facilitate assimilation, and some fraction of that knowledge must be fairly diverse, although still related, to permit effective, creative, utilisation of the new knowledge' (Cohen & Levinthal, 1990, pp. 135-136). Hence, new knowledge that is close to existing bodies of knowledge is more easily understood and eventually absorbed than distant bodies of knowledge.

While most contributions turn to the difficulty of uptaking and using knowledge as a function of knowledge relatedness, Hinds and Pfeffer (2003) turn to the difficulties in disseminating expert knowledge. They address and explain the problems an expert faces when aiming to share knowledge with a novice: 'Because experts begin to abstract and simplify their understanding of tasks as they become more expert, they may not be able to recall the complexity and details they and others require as novices to understand the task' (p. 8). The expert is confronted with the difficulty of recalling his own process of becoming familiar and proficient in the field and to put himself in the novice's position. However, recalling tends to be incomplete, inaccurate and often distorted. Hence, differences in expert status in regard to a specific type of knowledge can lead to an imbalance in information needs and information offers that can impede the process of knowledge sharing.

As a result, Malerba and Orsenigo (2000) warn that with increasing gaps in knowledge bases between two partners, 'two agents endowed with the same information may well end up doing different things because the cognitive structures of different individuals or groups are likely to be developed through experience, exposure to particular problems, etc. and hence their cognitive understanding of the same information is different' (p. 291). This quote illustrates again the contextuality of knowledge (see section 3.2). The same data and information derived from it can be understood differently when evaluated within different contexts.

The possible misrepresentation of knowledge by the sender or misinterpretation by the receiver can lead to friction, recrimination, frustration or delays to the project. Furthermore, in constellations of large technological distance, distortions in knowledge representation or interpretation can remain unnoticed over long periods, amplifying these problems (Hinds & Pfeffer, 2003). Given these difficulties, the joining of distant knowledge bases is sometimes seen as 'an adoption of innovation in itself' (Groen, 2005, p. 116).

Again, the channel-ratio model by Haworth and Savage (1989) can serve to illustrate frictions in communication when knowledge bases differ (see sections 4.4.2 and 4.4.3). Instead of being shaped by cultural backgrounds of the sender and the receiver, the 'phenomenal fields' of the sender and the receiver are now shaped by the professional as well as the scientific or technological domain in which the sender and the receiver are active. Conceptually, technological distance is the most direct predictor of 'relative absorptive capacity', understood as the ability of organisations to uptake scientific and technical knowledge from the partner, and 'relative disseminative capacity', understood as the ability to share knowledge in a way comprehensible to the partner (see section 3.3). Both, disseminative and absorptive capacity in inter-organisational co-operation, are thought to be strongly conditioned by the level of technological distance – or knowledge distance – between the partners.

Considering the trade-off between novelty value and the ability to share knowledge, Nooteboom and his colleagues (Nooteboom, 2009, 2004b, 1999; Nooteboom et al., 2006; Gilsing et al., 2008; Wuyts et al., 2005), as well as Mowery et al. (1998) assume an inverted U-shaped relationship between technological distance and the inventive performance of the co-operation (figure 4.5). It is proposed that firms should be sufficiently distant in resources – specifically knowledge and technical skills – to carry new knowledge; however, at the same time, they should be sufficiently close in knowledge and language to understand each other and eventually absorb the new knowledge provided by the partner into their existing knowledge base. The result is a function of 'inventive performance' as the aggregate function of the variables 'ability to collaborate' (downward slope) and 'novelty value' (upward slope) as determined by technological distance as independent variable. From this function, an optimum value of technological distance for inventive performance can eventually be calculated (Nooteboom 2009, 2004, 1999).

Moreover, prior related knowledge can be based upon different compositions of basic and specialised knowledge. Lubatkin et al. (2001) particularly emphasise the role of basic or general knowledge base similarities: 'the capacity to co-learn and discover, like the capacity to absorb, is dependent on the similarity of the partners' *general* knowledge base .... That is, the recognition and appreciation of each other's proprietary knowledge requires that the partnering firms must already possess a basic awareness of the semantics, episodes, and the articulable cause/effect linkages (or decision rules) that ground each other's knowledge structures. ... There can be no co-experimentation with abstract knowledge without both partners having the abil-

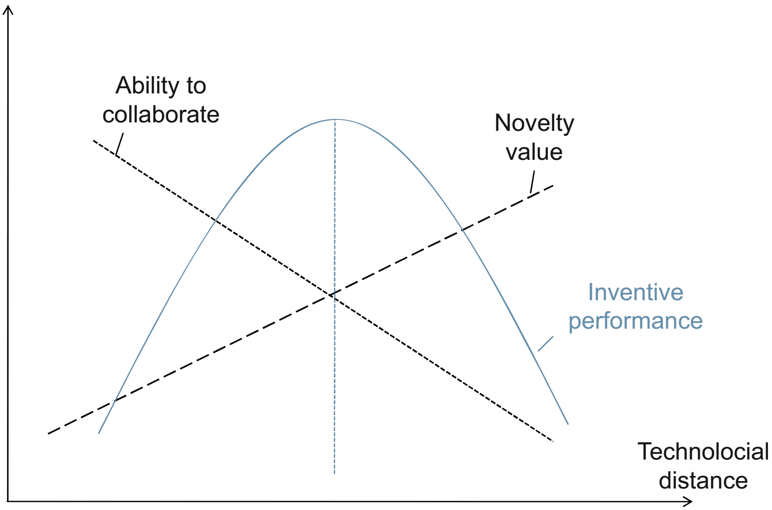

Figure 4.5: Determining the Optimal Level of Technological Distance (adapted from Nooteboom 2009, p. 105)

ity to speak the basics of each others' language' (p. 1366, emphasis added). Basic knowledge structures as found within academic disciplines possess their own codes, traditions and approaches. In the absence of an overlap in these basic knowledge structures, a particularly strong negative distance-effect is predicted (Olsen, 2009; Lubatkin et al., 2001).

Integrating the conceptualisation of different types of knowledge and expertise, ranging from more basic to more specialised domains as proposed by Lubatkin et al. (2001), the above considerations can be extended and more narrowly specified: it can be suggested that firms should be sufficiently distinct in their specialised knowledge to access complementary as well as new knowledge and sufficiently close in basic knowledge to facilitate knowledge sharing. On the other hand, it is presumably at the crossing of different base disciplines, where new revolutionary combinations are likely to occur, that renders inter-organisational co-operation even more difficult (see, e.g. Kodama, 1992).

For illustrative purposes, this notion of knowledge-base relatedness – considering different compositions of basic and specialised knowledge bases of the partners – is sketched in figure 4.6. Here, the overlap in the respective knowledge bases of two sample organisations, A and B, are depicted. The large circle delineates the basic knowledge upon which an organisation's knowledge base is composed, while the smaller circle delineates the organisation's specialised expertise.[31]

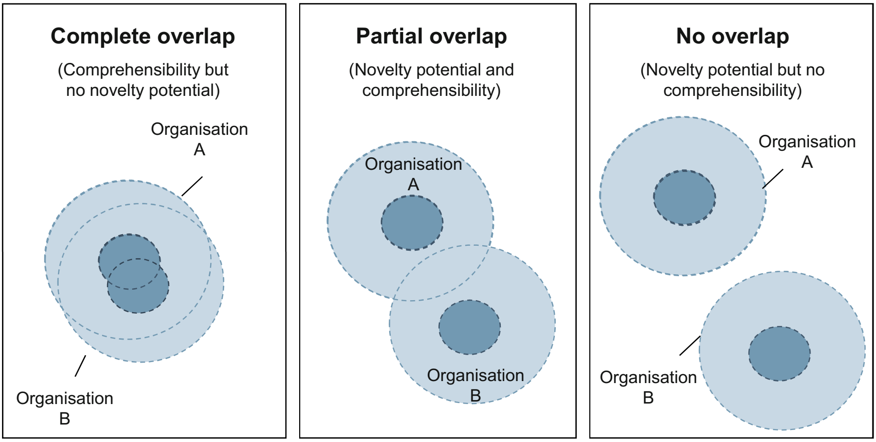

Figure 4.6: Determining the Optimal Level of Technological Distance: Basic and Specialised Knowledge Bases (adapted from D'Agata & Santangelo 2003, p. 11)

On the left-hand side of figure 4.6, the partners merely duplicate their knowledge bases in both their basic as well as their specialised bodies of knowledge. This constellation of large – although never full – congruency seems doubtful in its effectiveness, as it offers little added value (novelty potential) to the organisations; however, mutual scientific and technical understanding (comprehensibility) is the greatest. By contrast, in the right hand figure, there is no overlap in knowledge bases, not even the most basic ones. In such a situation, initial mutual under-

[31] The small circle can thus be interpreted as the peak of the mountain in a three-dimensional depiction, which is based on the fundament of the organisation's basic knowledge.

standing of the partners is thought to be low and the process of knowledge sharing difficult. The picture in the middle drafts a situation in which the knowledge bases of the partners are distinct, yet partial duplication of knowledge, particular in its basic constituents, exists. This area of overlap or 'redundancy'[32] (Tallman & Phene 2007, p. 252, Cohen & Levinthal 1990, p. 134, Nonaka & Takeuchi 1995, p. 80) contributes to mutual understanding, interpretation and exploitation of each others' knowledge, and a fruitful combination of the specialised domains. Hence, in the middle picture the firms are thought to be best prepared to combine each other's knowledge and expertise.

Besides, **motivational** drawbacks can add to the difficulties in inter-organisational knowledge sharing when high levels of technological distance exist between the partners. First, the level of technological or knowledge distance will influence the level of (perceived or factual) relational risks within a partnership. On the one hand, it can be assumed that relational risks are lower when the organisations share some scientific, technical or professional background, which allows them to assess the partner's knowledge and evaluate his behaviour (Nohria, 1992). Vice versa, the less the overlap in knowledge and expertise of the partners, the less they are able to assess the value of the other's resources and capabilities as well as his reliability, and the greater the risk inherent in the co-operation (Nielsen, 2007). On the other hand, knowledge can be more easily misappropriated when the partner is able to understand, absorb and first of all use the new knowledge.[33]

Second, more subtle motivational factors are reported by Leonard-Barton (1992), who observed the existence of a hierarchy between different disciplines within firms. In regard to new product and process development, she describes how the dominant disciplines and knowledge bases in which a firm historically excelled tend to suppress traditionally 'non-dominant disciplines' (p. 120) that are less well respected or less prestigious within the firm. This lack of esteem for and resistance to different disciplines or distinct knowledge bases often takes place in very subtle, non-observable

[32] Nonaka & Takeuchi (1995) introduce 'redundancy' as the possession of 'information that goes beyond the operational requirements of organizational members' that permits 'individuals to invade one another's functional boundaries' (pp. 80-81). Redundancy is perceived to play an important role in the integration of specialised bodies of knowledge within organisations (Grant, 1996).

[33] Note that competitive risks from strategic proximity were treated separately in section 4.4.4. The fact that organisations share basic knowledge – and also to some extent specialised knowledge – does not automatically imply that they are close competitors; although, both dimensions might be correlated.

ways, but can constitute a strong motivational boundary to adopt and integrate different knowledge bases. The same presumably holds in inter-organisational projects when different bodies of knowledge are combined.

This observation ties in with the discussion on group categorisation and its potential negative effects on team cohesion and knowledge sharing as discussed in sections 4.4.2 and 4.4.3. Relatedly, Cohen and Levinthal (1990) assume that the motivational drawback of the 'not invented here' (NIH) syndrome can eventually be traced back to a too great distance in knowledge bases. They claim that 'such ideas may be too distant from the firm's existing knowledge base - its absorptive capacity - to be either appreciated or accessed' (p. 137). Furthermore, new knowledge that is distant from existing bodies of knowledge and expertise can be perceived as threatening to the existing employees who fear the loss of their expert status (Hinds & Pfeffer, 2003). Although co-operation should be a mutual process, this balance in gaining and sharing is not necessarily perceived by those directly involved; and a prisoner's dilemma (see section 4.4.4) on the level of the individual experts might arise, where being the first to share expert knowledge might risk one's status without being refunded for the eventual loss. Moreover, on the part of the receiver, a perceived expert status might prevent the person from admitting a lack of comprehension. Hence, the motivation to share as well as uptake knowledge from other sources can be hampered when the technological distance between the partners is too large and the dissemination and absorption capabilities of those involved come to their limits. This points to the fact that knowledge is more easily exchanged within one 'epistemic community' (Cowan et al., 2000, p. 234), due to both greater technical understanding and a feeling of belonging and identity.[34]

Constitutive for SMEs is their absolute smaller number of employees. Hence, the breadth of knowledge present within a small or medium-sized firm is naturally narrower and tends to be more specialised.[35] While this calls for external complementation of knowledge and expertise through co-operation; it reduces the likelihood of

[34] Epistemic communities are groups of 'knowledge-creating agents who are engaged on a mutually recognized subset of questions, and who (at the very least) accept some commonly understood procedural authority as essential to the success of their collective activities' (Cowan et al., 2000, p. 234). Thus, they share the knowledge, drive and methodologies which contributes to mutual understanding, identity and shared motivation that allows to advance certain (scientific or technological) questions.

[35] However, it is not the absolute number of employees that is in the end decisive, but the relative composition of knowledge and the resultant overlap between the partners.

an area of overlap of knowledge and skills between the partners, which eventually renders the co-operation more difficult.

Taken together, technological distance seems important in order to create a requisite variety of knowledge and skills conducive for invention and innovation. However, important cognitive and motivational drawbacks have been identified that render inter-organisational co-operation in R&D with increasing degrees of technological distance more difficult. The general technical risk of failure is also thought to be higher when novel combinations are explored compared to the further exploration and exploitation along more traditional trajectories. Thus, outcomes, as well as competences and behaviour can often not be evaluated by the partners when they cannot properly comprehend the other's knowledge and the joint potential. Compared to the other dimensions, technological distance is most directly linked to the partners' ability to share knowledge. A lack of redundancy in knowledge bases is suggested to render knowledge sharing most challenging. As a by-product of the arduous processes of knowledge sharing, also the motivation of the partners to share knowledge can suffer. Moreover, this can be fueled by perceived rivalries between disciplines and approaches as well as threats to one's current expert status.

Empirical Evidence

A first set of studies investigates the impact of technological distance for partnership formation or partner selection. For example, Mowery et al. (1998) show that partnership formation can be predicted by the firms' technological overlap. Similarly, Cantner and Meder (2006), as well as Meder (2008), demonstrate that for a sample of German co-operative partnerships, technological overlap of potential co-operation partners is a predictor for co-operation formation. Thus, there seems to be a preference for partners who are close in their technological knowledge base.

With respect to the influence of technological distance/proximity on co-operation performance, as well as knowledge sharing and learning more specifically, an earlier study by Mowery et al. (1996) provides first evidence. Based on cross-citation rates of a sample of US strategic alliances, they analyse the extent of technological overlap pre and post co-operation. Their empirical results suggest that the more the partners' technological profiles resembled each other prior to the co-operation, the easier it is for them to absorb each other's knowledge, which they conclude from the partners' subsequent convergence in their patent portfolios. Similarly, Gomes-Casseres et al. (2006) found in a sample of alliances from the ICT sector that technologically proximate partners display higher cross-citation rates in patents after co-operation compared to technologically distant partners. They likewise interpret this finding as evidence for the existence of higher amounts of knowledge sharing and learning between technologically proximate partners. Probing the assumed differentiated effects of overlap in basic versus specialised knowledge bases of the partners, Lane and Lubatkin (1998) found that particularly basic knowledge base similarity is positively related to inter-organisational learning whereas the effect of specialised knowledge relatedness was not significant. However, no reference to the potential novelty value of technological distance is made in these contributions.

Recently, the concept of technological distance has been more prominently represented and empirically tested by Bart Nooteboom and his colleagues in regard to its effect on knowledge sharing as well as the inventive potential of the partnership (Gilsing et al., 2008; Nooteboom et al., 2006; Wuyts et al., 2005). Departing from the assumed trade-off between novelty value on the one hand and communicability as well as ability to absorb knowledge on the other, Nooteboom and his colleagues empirically validate their assumption of an 'optimal' level of technological distance that generates a maximum level of learning and novelty. In Wuyts et al. (2005), they create a measure of partner dispersion in regard to the number of different partners in a firm's co-operation portfolio to approximate the distance that characterises a firm's portfolio of R&D agreements in a sample of firms from the pharmaceutical industry, and analyse its effect on the likelihood of technological innovation in the form of a new drug application. The analysis corroborates the assumption of an inverted U-shaped function of partner dispersion where technological innovations are most likely to occur at intermediate levels of partner dispersion in the firm's co-operation portfolio. However, this variable is a crude indicator of technological distance. In Nooteboom et al. (2006), the unit of analysis turns to a specific alliance as incurred by the largest companies that are registered in the Merit-Cati co-operation database.[36] Technological distance is now approximated by the correlation between the technological profiles of the partners as derived from patent data. In turn, an inverted U-shaped relationship is established between the technological distance and the overall innovative performance of a firm, particularly in regard to the exploration of new fields that previously did not belong to the firm's

[36] For more information on this database, see Hagedoorn (2002) or http://www.nsf.gov/statistics/nsf01336/p1s3at.htm.

technological portfolio. In Gilsing et al. (2008), the unit of analysis turns again to a network level. The authors measure the effect of the technological distance of a firm's co-operation portfolio – measured as the average of the correlations between the focal firm's technology profile and that of each of its alliance partners – on the number of a firm's explorative patents, proxied again as the number of patents a firm successfully filed within patent classes in which it had not been active before the co-operation. Again an inverted U-shaped relationship between technological distance and inventiveness is established. However, the effect is mediated by the overall network structure and a firm's position within it, particularly the betweenness centrality, understood as the centrality of a focal firm in a network.

Likewise using patent data to determine technological diversity in a sample of R&D alliances in the telecommunications equipment industry, Sampson (2007) also corroborates the inverted U-shaped function of technological distance on inventiveness. She finds that alliances contribute most to a firm's patenting activity when technological diversity is moderate, rather than low or high.[37] In a similar fashion, Schoenmakers & Duysters (2006), using patent data as a measure of knowledge base overlap in a sample of strategic alliances, find that the degree of pre-alliance knowledge base overlap as a determinant of the post-alliance knowledge base overlap follows an inverted U-shaped relationship. They conclude that learning takes best place at intermediate levels of knowledge base overlap.

Next to these quantitative studies, Porac et al. (2004) provide a qualitative analysis of two distributed project teams that differ with regard to their inter-disciplinary variety of team compositions. Contrary to initial expectations, the authors did not observe any significant difference in the project outcomes between the two projects. By contrast, Jehn et al. (1997) have demonstrated that groups comprising diverse members in regard to educational backgrounds experience more incidences of conflict and general difficulties to proceed than groups in which the members are of similar educational backgrounds.

In summary, there has recently been considerable interest in and empirical evidence for the impact of technological distance on co-operation formation and inter-organisational learning, as well as on its effect on a firm's capacity to invent. The

[37] Note that all studies cited so far establish a relationship between technological distance and the inventive performance of the firm, not the co-operation project itself. Hence, they do not capture the immediate or direct effects of technological distance on performance and outcomes of the respective co-operation projects.

results so far corroborate the insights from innovation theory that the combination of distinct bodies of knowledge and skills yields novelty as well as from learning theory positing that learning is conditioned by what is already known; i.e., by existing bodies of knowledge yielding an inverted U-shaped relationship between technological distance, learning and novelty generation.

4.4.6 Relational Distance

Definition and Characterisation

Boschma (2005a) defines relational proximity as[38]

> '... *socially embedded relationships between agents at the micro-level. Relations between actors are socially embedded when they involve trust based on friendship, kinship and experience.'* (Boschma, 2005a, p. 66)

In his definition, Boschma draws on central concepts from social network literature (see section 2.4), particularly the notion of embeddedness, which has been defined as 'the fact that exchanges typically have a history, and that this history results in the routinisation and stabilisation of linkages among members' (Gulati, 1998, p. 295, referencing Marsden, 1981, p. 1210). As consequence Granovetter (1985) outlines that 'actors do not behave or decide as atoms outside a social context, nor do they adhere slavishly to a script written for them by the particular intersection of social categories that they happen to occupy. Their attempts at purposive action are instead embedded in concrete, ongoing systems of social relations' (p. 487). While the first definition stresses history and routinisation of relationships, the latter underscores the effects; i.e., the benefits and constraints of social relationships and networks, offering possibilities, but also constraining behaviour (see section 2.4).

[38] Boschma (2005a) uses the term 'social proximity'. Although both terms, 'social proximity' and 'relational proximity', have been used to equal extents and are associated with similar interpretations in the literature (Knoben & Oerlemans, 2006), 'social proximity' is here interpreted as a broader concept that, for instance, also includes a resemblance in social characteristics (e.g., status), without a direct relationship between the organisations. As this dimension is meant to comprise direct or indirect links in a network, the term 'relational proximity' is preferred.

Social relationships can comprise different kinds of ties, from personal ties based on friendship to business ties based on resource exchanges. Moreover, different kinds of ties can interfere and add leading to multiplexity. As a result, actors can improve their position in one network by taking advantage of their position in another network. For example, they can use a network of friends to establish a new business relationship (Sydow, 1992). The perspective now extends the immediacy of a direct tie between two organisations to include network ties of a higher order; i.e., indirect ties. Seizing these insights, relational proximity comprises direct and indirect ties of different types and strengths. The more (less) intensive (in terms of degree, type, multiplexity and strength) a network tie is, the more (less) embedded a relationship is thought to be and the higher the level of relational proximity (distance).

Similar to the technological dimension, relational ties reside at the level of individuals; i.e., at the micro level. However, they accumulate to form the collective network of an organisation (Ferru, 2009; Burt, 1992a).

Expected Impact on Inter-Organisational Co-operation in R&D

In current network and innovation studies, there is a growing awareness that too close ties, as manifest in enduring or repeated relationships, can prevent the in-flow of new ideas and lead to lock-in effects. Close ties offer a great depth of knowledge but little diversity (Lorentzen, 2008). It follows that, with regard to interactive learning and novelty generation, existing ties can prove dysfunctional as 'too much familiarity may take out the innovative steam from collaboration' (Gilsing et al., 2008, p. 1719).[39] Thus, through the accession of new ties, novel combinations are more likely to arise, and firms can profit from 'visionary advantages' (Rowley & Baum, 2008, p. xvi) through access to diverse information, new ideas and resources.[40]

[39] Remember Coleman (1990) who has been cited in section 2.4, suggesting that 'a given form of social capital that is valuable in facilitating certain actions may be useless or even harmful for others' (p. 302). This is particularly true in R&D, where novel combinations increase the likelihood of the generation of more radical, groundbreaking novelty (Thune, 2006; Rosenkopf & Almeida, 2003; Duysters et al., 1999; Granovetter, 1973; Burt, 1992b).

[40] Note one caveat of this argument: For example Gilsing & Nooteboom (2005) acknowledge that the inventive potential of a given partnership does not necessarily decrease as long as both partners uphold ties with other (changing) partners and thus regularly refresh and expand their knowledge base.

However, the accession of new ties comes at the expense of certain relational advantages, mostly referred to as 'social capital'.[41] Nahapiet and Ghoshal (1998) discuss the impact of social capital for intra-organisational knowledge sharing. They distinguish between three dimensions of social capital: structural, cognitive and relational. These are thought to exert a strong influence on the ability and motivation of people and organisations to share knowledge; both within as well as across organisations.

In section 4.4.3, incompatibilities in organisational cognitive foci, structures, routines or scripts have been discussed as potential impedance factors, exerting a negative effect on the **ability** of the partners to collaborate. Thus, regarding the *structural dimension* of social capital, it can be assumed that firms who had prior ties will be acquainted with and aware of the goals, structures, rules, routines and procedures each follows (Gulati, 1998). This includes experience of who to approach with certain issues ('know-who', Johnson et al. 2002). Moreover, they will already have implemented specific mechanisms and routines for inter-organisational co-ordination that support inter-organisational knowledge sharing (Zollo et al., 2002). Thus, Uzzi (1997) contends that socially embedded relationships yield economies of time as each understands the other's organisational set-up and operation. Team members will not distract time and effort for operational alignment, negotiation and information-gathering processes, but can concentrate on the actual collaboration. This partner-specific experience is cumulative and will increase the ability of those involved to efficiently collaborate in any later relationship.

The *cognitive dimension* refers to 'those resources providing shared representations, interpretations and systems of meaning among parties' (Nahapiet & Ghoshal, 1998, p. 244). These manifest themselves in a shared language as well as shared narratives. Mutually experienced partners can build on earlier established codes, a shared vocabulary and experience in the use and meaning of (technical) terms commonly referred to in the partner organisation. Furthermore, knowledge previously accessed by one organisation from another is likely to have been incorporated into its internal stock of knowledge. These prior investments in mutual understanding will have reduced the level of technological distance between the partners (see section 4.4.5). Thus, building on experience in each other's knowledge domain, future absorption of knowledge will be eased and dissemination tailored to the needs of the

[41] Social capital has been defined as 'the sum of resources, actual or virtual, that accrue to an individual or group by virtue of possessing a durable network of more or less institutionalised relationships of mutual acquaintance and recognition (Burt, 2001, p. 2, referencing Bourdieu and Wacquant 1992, p. 119, see section 2.4).

partner. In line with Nahapiet and Ghoshal's argument, relational proximity will lead to more realistic expectations about and a better anticipation of the partner's needs and capabilities, as well as the combined potential of each other's resources.

Returning to the communication model of Haworth and Savage (1989), two conclusions can be drawn. First, prior interaction will have led to a dilation of the circles characterising the respective phenomenal fields of the partners. Through this, the intersection area will have increased, implying that sender and receiver need less explicit information in order to infer suitable information from a message. Second, the sender will know better which levels of explicit knowledge the counterpart needs in order to correctly interpret and act on the information received, and the receiver will be better prepared to infer meaning from implicit parts of knowledge and be able to interpret non-verbal messages. Phrased differently, 'two actors that are strongly tied tend to have developed a relationship-specific heuristic for processing non-codified knowledge between them' (Hansen, 1999, p. 88). This directly supports the partner's ability to share knowledge.

The *relational dimension* of social capital is foremost related to the **motivation** to share knowledge. Considering the inherently uncertain nature of R&D and the avenues for opportunistic behaviour, the partners can be expected to be initially hesitant about fully disclosing their knowledge to 'strangers' (Inkpen, 1998, p. 74). Relational proximity can mediate the perceived level of risks. It can be expected that with higher degrees of experience with a partner, the content and quality of his knowledge as well as his behaviour within the co-operation will have been proved, raising the levels of trust in the partner's competences and behaviour. This increased level of trust will in turn result in greater openness toward the partner. Nooteboom (2009) assumes that 'trust requires familiarity and mutual understanding and, hence, depends on time and context, habit information and the positive development of a relationship' (p. 30). Similarly, Alm and McKelvey (2000) stress that trust is essentially related to learning about co-operation partners and needs time. Also Gulati (1998) highlights informational and time benefits within a given co-operation relationship, as it is more likely that partners will timely be provided with sensitive information at critical junctures in the co-operation project. Furthermore, Gulati assumes that relationally proximate partners will promote greater frequency of contact and information exchanges. It is also suggested that relational proximity will contribute to 'affective' (a feeling of emotional attachment) next to 'normative commitment' (a feeling of obligation), which is believed to increase the motivation to contribute to the project (Nahapiet & Ghoshal, 1998).

This argument is in line with game-theoretical arguments as provided by Axelrod (1984). Axelrod suggests that with the expectation of repeated games, the partners tend to refrain from opportunistic behaviour due to expected positive gains in any future period. Thus, repeated interaction leads to a greater likelihood that the partners conform to the agreement.

The benefits of social capital, particularly in its relational dimension, extend the bilateral tie. Thus, belonging to the same social network can result in higher levels of trust in the partner's competence and behaviour based on calculation, shared norms and common cognition in a network (Narula & Santangelo, 2009; Hite, 2008; Gulati et al., 2000). Gulati et al. (2000) argue that network ties 'facilitate due diligence so that each partner has greater knowledge about the other's resources and capabilities and greater confidence in their mutual assessments' (p. 209). Through referrals from third parties, information concerning the quality of resources and the behaviour of the partner can be accessed. Besides, social networks convey behavioural trust due to shared rules, norms, obligations and a shared identity. They define and follow their own 'rules of the game' and possess their own means to enact them. Deviating behaviour is more likely to be revealed in a dense personal net of ties and more costly as the defecting organisation would risk damaging its reputation and standing within the broader network (Gulati et al., 2000). Thus, social networks preside over a set of sanctioning mechanisms (including the exclusion from the network), which contribute to align behaviour and convey trust (Gulati, 1998). It can be expected that partners embedded in a shared network will rather refer to 'loyalty' or 'voice' strategies in the case of conflict than 'exit' strategies (Hirschman, 1970). Hence, they can be characterised by a higher resistance to survive conflict. Similarly, Dhanaraj (2004) argues that, especially in turbulent environments, social aspects may play a critical role in knowledge transfer.

Conversely, if relational distance is high – i.e., if an inter-organisational co-operation builds on no earlier or only very weak social ties – the investments to establish structural, cognitive and relational social capital will need to be carried out within the co-operation project. This can hamper knowledge sharing and increase transaction costs. In this respect, Inkpen (1998) suggests that 'inexperienced partners must go through a relationship building process that may interfere with learning' (p. 76).[42]

Drawing on these opposite directions of the relationships between inventive potential on the one hand and social capital on the other, Nooteboom (2009) assumes the potential of a relationship to be a function of its duration and assumes the existence of an optimal level of duration of a relationship after which its inventive potential decreases. While duration is one aspect, intensity and multiplexity of the relationship are others. Together, the argument points to an inverted U-shaped relationship between relational distance and the outcome of a relationship.

Taken together, relational distance contributes new ideas and capabilities. On the other hand, novelty of ideas usually comes at the expense of social capital, which is perceived to convey certain structural, cognitive and relational advantages for the partners. Through prior experience, the partners share cognition, rules, codes and knowledge that supports their ability to share knowledge and co-ordinate the project across organisational boundaries. Hence, relational proximity exerts a rather indirect impact on the ability of the partners to share knowledge, primarily through strengthening technological and organisational proximity. Further, relational proximity, also through third parties or networks, can either intrinsically (e.g., through trust, the presence of a shared identity and feeling of belonging) or extrinsically (e.g., through reputation losses or the threat of exclusion from the network) raise the motivation to contribute to a relationship. As Nelson and Winter (1982) note, 'embeddedness allows for the social infrastructure that is needed for absorbing new information' (p. 112).

Empirical Evidence

First, there is empirical evidence that organisations tend to replicate earlier ties or form new ties with partners' partners. Gulati (1995b) and Gulati and Gargiulo (1999) were among the first who systematically analysed the impact of network embeddedness on new tie formation. Investigating alliances of US firms in three different industries, they found evidence that not only prior mutual alliance activity increases the likelihood of new tie formation, but also indirect links through common third parties. Based on German co-patent data, Cantner and Meder (2006)

[42] This is comparable to what Johanson and Vahlne (2009) recently called 'liability of outsidership'.

replicated these findings for German firms, confirming that previous business relationships between firms increase the probability of further co-operation. Grossetti and Bès (2001) showed in a study on firm–university relationships in France that 44% of relationships can be traced back to prior social ties. Among these, the professional network, such as former colleagues, ranks highest, followed by acquaintances from prior studies and non-professional networks, such as family or friendship. The study by Rosenkopf et al. (2001) extends these insights, relating both previous partnership as well as joint technical committee activity to new partnership formation. They show that both types of prior relationships individually exert an inverted U-shaped relationship on new partnership formation. Moreover, both types of relationships combined decrease the likelihood of subsequent partnership formation. Both findings suggest that, beyond a threshold, the combination of different types of relationships leads to over-embeddedness, decreasing the likelihood of further co-operation.

Second, turning to the evidence regarding the effects of previous co-operation and other relational ties on the course and outcome of a co-operation project, ambivalent results are reported in the literature. In a sample of 414 pharmaceutical firms, Kim and Song (2007) found a significant positive relationship between prior ties and joint invention as measured by the application of joint patents. They assume that the level of trust built during previous relationships plays a major role to encourage the partners to share their knowledge. Similarly, Zollo et al. (2002) found in a sample of 145 biotechnology alliances that partner-specific experience has a positive impact on co-operation performance in terms of the firm's satisfaction with the co-operation and the creation of new opportunities for the firm. Also Nielsen (2007) established a positive effect of prior experience with the partner on the subsequent financial performance of the firm and the learning it could derive from the co-operation. By contrast, Hoang and Rothaermel (2005), similarly analysing the effectiveness of joint R&D projects in the biopharmaceutical industry, found a positive, though insignificant, linear regression coefficient of the independent variable dyadic experience on success as measured by officially approved, marketable new drugs, while the squared term was negative and marginally significant. They concluded that with increasing partner-specific experience, the probability of joint R&D project success decreases. Similarly, Saxton (1997) observed that prior affiliation between co-operation partners was linked to higher levels of initial satisfaction with the co-operation, but not to longer-term benefits to the partners. He concluded that, although affiliation has been demonstrated to increase the propensity to engage in co-operation, it does not have a commensurate impact on its subsequent performance. According to him, continued partnering with the same firm could reflect inertia or the institutionalisation of a relationship, instead of mutual trust and commitment. Thus, while some variance in the results may be due to different dependent variables, the impact of relational proximity/distance is still unsettled.

Additional insights can be gained from network studies. For example, Wuyts et al. (2005) suggested that repeated interaction with the same partner leads to a lower level of cognitive distance between the partners that reduces the innovative outcome of a partnership. In their empirical study of the biotechnology industry, they approximated repeated ties with the degree of dispersion of a firm's partnership portfolio. According to their empirical results, the degree of portfolio dispersion follows an inverted U-shaped relationship on the dependent variable 'likelihood of technological innovation' as measured by new drug applications. That is, with rising levels of portfolio dispersion, the likelihood of innovative outcomes first rises and then decreases again with excessive levels of partner portfolio dispersion. They concluded that this empirical relationship indirectly provides support for the hypothesis that repeated ties lead to cognitive convergence that, at some threshold level, decreases the likelihood of innovation. Similarly, Hagedoorn and Frankort (2008) provide evidence on dyadic over-embeddedness in IBM's network of R&D partners. They observe that repeated ties occur but have a limited life span after which new ties are entered and old ones are abandoned. For them, this observation supports the hypothesis that repeated partnerships decrease in their value after some threshold level of growing returns.

Two further studies on the role of structural holes provide valuable, though contradicting, insights. According to the results of Zaheer and Bell (2005), innovative firms that bridge structural holes achieved a further performance boost. That is, by spanning a structural hole, the firms in their sample were rewarded with higher inventiveness, which argues for the benefits of relational distance. By contrast, Ahuja (2000), in a sample of 79 of the leading firms from the chemical industry, found that a higher number of ties that spanned structural holes was not conducive to firm inventiveness.

Together, the current evidence on the impact of relational distance/proximity for inter-organisational co-operation is mixed. There is evidence for both, the supporting role of social capital as well as the potential risk of inertia and a lack of in-flow of new resources and ideas.

4.5 Relative, Combined and Interaction Effects

While the achievement so far has been to single out potential effects attributable to any one dimension, another central claim has been to investigate the relative weight, interdependence and interplay of different dimensions of distance. Following Boschma and Frenken (2009), the separate theoretical discussion of each dimension now allows to assess:

1. the relative impact of different dimensions of distance;
2. interdependencies between different dimensions, as well as
3. indirect or interaction effects between different dimensions.

First, regarding the **relative impact** of different forms of distance, two aspects are highlighted: 'ability versus motivation' and 'primary-task relatedness'. In sections 4.4.1 to 4.4.6, the different forms of distance have been discussed with respect to their impact on the partners' ability and motivation to share knowledge. While ability defines the fundamental (cognitive) capacities of the partners to share knowledge, motivation has been described as an activating element, intrinsically or extrinsically impelling the partners to contribute (see section 3.3). Within the discussion of each dimension, it has become evident that some dimensions are closer related to the (cognitive) ability to share knowledge (particularly technological, organisational and institutional distance), while others are primarily affiliated with the motivation to share knowledge (particularly strategic and relational distance). Thus, a different impact of these on the success of the project is expected. It is suggested here that an inability to share knowledge is a more fundamental impediment to knowledge sharing compared to motivational factors, exhibiting a stronger effect on the level of success of a co-operation (see, e.g., Szulanski, 2006).

Next, it is suggested that the closer a dimension is related to the primary value-generating activity the stronger its impact in regard to both the ability and the motivation to share knowledge (Sirmon & Lane, 2004). In particular, it has been argued that the partner's knowledge and skills which define the technological distance between them is the most direct predictor of their ability to share knowledge. The language, knowledge and also culture epistemic communities share can be suggested to weigh stronger than for example organisational and institutional distance.

In turn, empirical evidence suggests that organisational distance is a stronger predictor of knowledge sharing impediments than institutional distance, for it is again closer related to the primary value-generating task (e.g., Pothukuchi et al., 2002; Park & Ungson, 1997). Likewise, it has been suggested that social categorisations based on skills and academic background, as well as a potential fear to lose one's expert status, are most directly linked to the primary value-creating activity and most salient to the participants. Thus, categorisations based on scientific disciplines, for instance, can be expected to exert the greatest influence on the motivation to participate, followed by organisational affiliation and institutional belonging.

Second, **interdependencies** between different dimensions are expected (Boschma & Frenken, 2009). It has been stated in section 4.2 that the coupling of different forms of distance, respectively proximity, can constitute strong centripetal forces leading to regional cohesion and dense local network patterns. On the other hand, the decoupling of different dimensions can also constitute strong centrifugal forces which lead to global networks of ties. This is illustrated with the example of geographic and relational proximity. While Boschma and Frenken suggest that relational proximity is more likely to be found at geographic proximity, others assume that relational ties can extend geographic confines (e.g., clusters) and that these constitute strong centrifugal forces for international co-operation (e.g., Bouba-Olga & Grossetti, 2007; Agrawal et al., 2006; Breschi & Lissoni, 2006).

Third, and most centrally, it is suggested that different forms of distance, respectively proximity, can complement or substitute each other (**interaction effects**) (Boschma & Frenken, 2009; Boschma, 2005a; Knoben & Oerlemans, 2006). For example, Singh (2005) demonstrated that inventors working in the same field incur on average longer geographic distances. Thus, technological proximity seems to substitute for geographic distance. This finding is in line with the statement by Breschi and Lissoni (2001) that 'epistemic communities may well survive the end of co-localisation among their members. Even when dispersed in space, the latter will share more jargon and trust among each other than with any outsider within their present local communities' (p. 991). Vice versa, it might be suggested that geographic proximity substitutes for technological distance. Further, Ponds et al. (2007) found that geographical proximity is of smaller relevance for research collaborations between academic organisations, as opposed to collaborations between academic and non-academic organisations. Thus, also organisational and geographic proximity seem to substitute each other. Moreover, Shipilov et al. (2007) have been cited in section 4.4.1, who showed that non-local ties were initially negative and only payed off with repeated interaction. This suggests that close relational ties, i.e., relational proximity, can support knowledge sharing across geographic distance.

In this vein, it is one of Boschma's central arguments that 'geographical proximity may facilitate inter-organisational learning, but it is neither a necessary nor a sufficient condition. It is not necessary, because other forms of proximity may function as substitutes to solve the problem of coordination. It is not sufficient, because learning processes require at least cognitive proximity besides geographical proximity' (p. 71). Integrating the previous discussion of the effects expected from each single dimension, this contention is shared. Geographic distance has been suggested to primarily exert an influence on the frequency, quality and costs of interaction and co-ordination (see section 4.4.1). However, whether the switch to ICT as primary interaction media has a negative impact on knowledge sharing can be suggested to be a function of the amount of shared codes, knowledge and cognition between the partners. This will also have an impact on the desired frequency of face-to-face encounters, the choice of communication media and thus the costs of interaction.

Next – considering the theoretical discussion of the constituents of social capital – relational proximity is likewise assumed to have an indirect impact. Borrowing from Nahapiet and Ghoshal (1998), three dimensions of social capital were introduced: cognitive, structural and relational. The first two dimensions are related to the technological and organisational dimension of distance, respectively. That is, through previous relationships, the partners will be acquainted with the specific knowledge, skills and codes of the partner, which allows them to better comprehend the partner's knowledge and skills and to share knowledge. Moreover, the partners will already be familiar with the organisational characteristics of each other and they can build on previously established inter-organisational routines. In this sense, relational proximity is thought to exert an indirect effect; in particular mediating the effects of technological, institutional and organisational distance.

Summarising these considerations, Boschma and Frenken (2009) contemplate that 'in sum, optimal levels of proximity may enhance network performance, but the location of an optimum along one proximity dimension depends most likely on the location along other proximity dimensions at the same time' (p. 7). This is an important insight; however, empirical insight regarding the interplay of different dimensions to date is thin (Broekel & Boschma, 2009).

4.6 A Differentiated View on Learning and Novelty Generation

While most contemporary studies treat inter-organisational co-operation in R&D as one entity, two additional variables are discussed that might further influence the process of knowledge sharing – and thus the impact of different dimensions of distance – within inter-organisational co-operation projects: the **invention stage**, separated into research and development (section 4.6.1); and the **learning rationale**, distinguishing between learning *from* the partner from learning *with* the partner (section 4.6.2).

4.6.1 Different Stages of Novelty Generation

In section 1.4, different stages within the invention process have been discussed. Broadly, the invention process can be distinguished into a **research stage** which aims at the generation of new knowledge and a **development stage** which serves to generate marketable products, processes or services. Accordingly, both stages differ in their goals, activities, characteristics and challenges, which eventually has an impact on the process of inter-organisational co-operation and its sensitivity toward distance in different forms.

In particular, research is typically characterised as experimental, open-ended and creative work which serves to generate new knowledge. This has two implications for inter-organisational co-operation. First, new or emerging knowledge as produced within research tends to be initially implicit in the heads and operating procedures of those who have generated it. Hence, the knowledge produced in research activities is typically initially tacit, contextual and often causally ambiguous. Rational and logical description sometimes cannot be given yet and 'know-how' at times precedes a causal understanding of the underlying mechanisms ('know-why') (Olsen 2009, Johnson et al. 2002, Nonaka, 1990, 1994). In this sense, Nooteboom (1999) suggests that 'tacitness of knowledge depends on how novel it is' (p. 16). This new knowledge might lack a 'codebook' (Cowan et al., 2000, p. 225) in the sense of a shared vocabulary to articulate and share it with others (Johnson et al., 2002; Saviotti, 1998; Leonard-Barton, 1995). Second, research has been described as an experimental, open-ended activity of which the results are not necessarily foreseeable. This characteristic opposes a well-structured process and a clear division of work between the partners. Moreover, the partners can be faced with difficulties in specifying later ownership rights at the beginning of the project as long as the results are not foreseeable in detail.

Contrariwise, it is expected that in development, the partners already have a relatively good understanding of the technical issues at hand. This better understanding allows a verbal description as well as codification of central mechanisms, relationships and procedures. Furthermore, the process is typically more structured, following certain rules and protocols, which makes it is easier to draft distinct work packages and to divide labour among the partners. Zollo et al. (2002) suggest that a higher degree of division of labour with a clearer allocation of responsibilities will lead to fewer uncertainties and co-ordination difficulties between co-operation partners. As the results are foreseeable at the beginning, more detailed contracts can be devised which reduces relational risks.

However, two counter-arguments are found in the literature. First, contrarily to the above argument, some argue that research activities tend to depend more centrally on 'know-why' than development activities which stronger rely on craft-like and procedural knowledge; i.e., on 'know-how' (Moodysson, 2008). Hence, knowledge sharing would be prone to greater difficulties in co-operative development compared to co-operative research. Second, the separation between research and development is not clear-cut. Invention is argued to be a recursive process, where particularly in development activities new questions might arise which necessitate again more fundamental research activities (Grupp, 1998; Kline, 1995).

4.6.2 Different Forms of Learning

In section 1.4, two different forms of learning in inter-organisational co-operation have been introduced: **learning *from* the partner**, also referred to as knowledge absorption co-operation, and **learning *with* the partner**, or reciprocal learning (Child et al., 2005; Lubatkin et al., 2001). While the first form of inter-organisational co-operation serves to adopt the knowledge and capabilities from the partner (strong learning intent), the latter aims to access and combine distinct knowledge bases to form something new (weak learning intent).

In particular earlier research on strategic alliances often assumed a strong learning intent of the partners (Nooteboom, 1999; Inkpen, 1998; Khanna et al., 1998; Lane & Lubatkin, 1998; Hamel, 1991). This view is most markedly expressed in the work of Hamel (1991), who observes that inter-organisational co-operation frequently leads to a reapportionment of skills between the partners and summons firms to adopt an explicit learning intent to win the 'competition for competence' which he perceives as characteristic for inter-organisational co-operation. As a result, the knowledge and technological bases of the partners subsequently converge.

Others, specifically Grant and Baden-Fuller (2004), vote for a differential view on inter-organisational co-operation, motivated primarily by the quest to access complementary resources and capabilities from the partner in order to fill resource gaps in the own organisation. Access in this sense is marked by a division of labour or mutual co-specialisation, where the firms are not eager to outlearn each other. This idea has been expanded by Lubatkin et al. (2001) to situations of inventive interaction between organisations. Lubatkin et al. assume that firms – faced by a convergence of technologies and the need to combine different knowledge bases – engage in processes of reciprocal learning where each partner brings in his specialised knowledge and expertise. Through this combination, each partner can leverage the other's expertise without having to invest into knowledge-building internally. This leads to a different pattern in respect to the convergence and divergence of the knowledge bases of the partners: While necessitating initial levels of convergence to enable communication, the partners subsequently engage in a process of mutual specialisation, leading to divergent, although complementary, knowledge bases.

The study of Mowery et al. (1996) provides interesting empirical insights on these divergent learning paths in inter-organisational co-operation. One of the prime results of their empirical investigation on knowledge transfer in strategic alliances is that 'significant inter-firm transfer of knowledge and technological capabilities occurs in only a subset of alliances, characterized by "convergent development" ' (p. 89). However, there is also a subset of partnering firms which displayed divergent development. In these cases, firms displayed declining technological overlap over time suggesting that in these cases, strategic alliances 'are vehicles for accessing rather than acquiring capabilities' (p. 89). These cases provide evidence for a permanent division of R&D work between organisations. Mowery et al. (1996) concluded that there are different strategies to learning within inter-organiational co-operation and underscored the need for a better definition of learning in theoretical discussions.

Hence, both situations are likely to exist, depending on the precise motives of the respective partners (Lubatkin et al., 2001).

It can be assumed that different learning strategies necessitate different investments in knowledge sharing. Thus, a strategy to learn from the partner is thought to imply a closer interaction with the partner compared to a strategy of mutual co-specialisation. This in turn might lead to different sensitivities of the partners in regard to different forms of distance in inter-organisational co-operation.

4.7 Summary

Based on the insights of the benefits and challenges of inter-organisational co-operation in R&D, particularly in regard to the process of knowledge sharing, gained in Chapters 2 and 3, this chapter set out to scrutinise the impact of distance in different forms understood as important contextual variables influencing inter-organisational knowledge sharing.

This argument builds on a recent line in innovation research which aims to disentangle the determinants of interactive learning and novelty generation. In the light of increasing organisationally and globally distributed innovation activities, current views suggest it to be insufficient to discuss the role of geographic proximity without filling it with the socio-economic or socio-cognitive relations that underpin and shape economic interaction, interactive learning and novelty generation. Thus, the inclusion of insights from social theory, particularly the logic of belonging and the logic of similarity, are central. This argument has been most markedly advanced by a research group called 'Economics of Proximity' or 'Proximity Dynamics'. The main contribution of this group is to separate geographic proximity from other forms of proximity which are thought to underpin interactive learning and novelty generation and to offer conceptual frameworks for analysis. Moreover, building on the recent acknowledgment of a 'proximity paradox', distance in some dimensions is currently proclaimed as an important lever for superior learning and novelty.

From the literature, a taxonomy of six forms of distance has been derived and discussed in this chapter: geographical, institutional, organisational, strategic, technological and relational. For each dimension, this chapter has offered a definition, an in-depth discussion of potential effects, in terms of benefits and liabilities, as well as a review of current empirical evidence. With inter-organisational co-operation in R&D being a knowledge-based activity, the discussion of the effects of the different dimensions has drawn primarily on insights into the processes and challenges of inter-organisational knowledge sharing, in particular the ability and motivation of the partners to share knowledge which had been identified as key determinants.

As a first step, these different forms of distance need to be understood in their single effects. Yet, in reality, a co-operation project is characterised by a layering of these different forms and their interplay. Thus, in a subsequent step, their combined effects need to be considered. In this vein, an important amendment has been offered by Boschma and Frenken 2009 who underscore that the impact of any individual form depends on the level of distance between the partners in the remaining dimensions. Hence, also the optimum level conducive to learning and novelty generation in one dimension deviates from the global optimum simultaneously considering the entirety of different forms of distance and their expressions.

Further, two variables have been discussed that are suggested to further influence the reach and effects of different forms of distance in inter-organisational co-operation in R&D. First, it has been suggested that research differs from development in regard to the possibilities to share knowledge, as knowledge is often initially not fully understood and tacit. Moreover, the possibilities to structure the co-operation project and formally fix the contributions and outcomes in detailed contracts are restricted. Contrarily, development builds on existing knowledge and is thought to be more structured. On the other hand, development activities often build on hands-on knowledge which is embodied in the scientists and assumedly hard to express. Second, two different learning rationales have been distinguished: co-operation in R&D can either constitute a learning vehicle to internalise the knowledge and skills of the partner or be an expression of a deepening division of labour. In the first constellation, the partners will subsequently converge in their knowledge basis and capabilities, whereas in the latter constellation, a divergence in knowledge and skills is expected. Both different invention stages and learning rationales can display different sensitivities towards distance between the partners in different dimensions.

A detailed summary of the expected effects is dismissed here as it follows in Chapter 5, where the main conclusions from theory and existing evidence are synthesised into a set of hypotheses for the empirical investigation.

5 Hypotheses

From the theoretical discussion in Chapter 4, twelve hypotheses are formulated for the empirical investigation. They first address the impact of different forms of distance for interactive learning and novelty generation, regarding single effects as well as their relative importance and interplay. Second, two hypotheses consider the impact of the intermediating variables (invention stage; learning rationale). The third complex of hypotheses addresses the role of management to respond to these challenges by organising proximity within the project.

Impact of different forms of distance and their interplay

In regard to **geographic distance**, it is claimed that firms might seek to leverage the 'best' partner or explore novelty in ideas and approaches by reaching out far. However, geographic distance itself is expected to lead to a reduced frequency of interaction and a potential shift in communication means in favour of less content and context-rich media which together renders knowledge sharing more challenging. Simultaneously, the costs of interaction and co-ordination increase. Together, this eventually leads to delays in project time lines, exerts greater personal strain on those involved, hampers learning and is accompanied by reduced levels of trust in the partner. Thus, the following hypothesis is to be tested:

1. *The effect of increasing geographic distance on the achievement of the project's goals is negative. This is foremost driven by deficiencies in the project's efficiency (operational outcomes), reduced learning coupled with increased personal strain (personal outcomes) and liabilities in relationship building (relational outcomes).*

Institutionally distant partners might be sought in order to leverage excellence in specific scientific or technological areas of other countries, as well as new ideas and insights. With different national systems favouring different technological specialisations and strengths, firms can profit from these by linking up with partners from the respective countries. Further, the diversity of ideas, approaches and contexts

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found in culturally mixed teams can yield novel combinations and creative solutions. On the other hand, differences in cognition and language are supposed to have a negative impact on knowledge sharing with rising levels of distance. Furthermore, higher (perceived) relational risks can lead to a lack of trust and reduced openness in communication. Similarly, national belonging might favour group thinking which risks team coherence. Opposing these effects yields the following hypothesis:

2. *The relationship between increasing institutional distance and the achievement of the project's goals follows an inverted U-shaped relationship. Increasing institutional distance between the partners is supposed to have a positive impact on the level of inventiveness of the project (inventive outcomes) as well as the realisation of strategic goals (strategic outcomes). However, beyond a threshold, this positive potential is increasingly difficult to exploit and also leveled out by a lower level of performance in regard to operational (efficiency), personal (satisfaction) and relational outcomes.*

Being manifest in differing 'deep-level cognitive structures' as well as deviating 'surface regulations', increasing levels of **organisational distance** can impede inter-organisational knowledge sharing through incompatibilities in goals and time lines, organisational routines or scripts and codes of communication. Besides, social exclusion mechanisms manifest in a lack of motivation to share knowledge with and adopt knowledge from 'outsiders' have been discussed; all of which exert a negative impact on knowledge-sharing. Hence, the following proposition is formulated:

3. *The effect of increasing organisational distance on the achievement of the project's goals is negative. This is particularly pronounced in regard to the project's efficiency (operational outcomes) and the personal satisfaction with it (personal outcomes).*

In cases where **competitive considerations** interfere within co-operative relationships, two ambivalent effects have been discussed: on the one hand, these constellations can be highly inventive and streamlined, as the partners are motivated to derive maximum benefit from the co-operation project. On the other hand, the partners might feel a tension between overtly sharing and protecting knowledge which is considered as critical to retain or gain the competitive lead. Under these circumstances, 'learning races' might occur where each partner tries to absorb knowledge from the other without revealing too much of himself. Hence, the direction of the effect of strategic distance, respectively proximity, is not clear. Thus, two rivaling propositions have been formulated:

4a The effect of increasing strategic proximity on goal achievement is positive, as the partners are motivated to derive maximum benefit from the co-operation project. This is mainly driven by a positive effect of strategic proximity on the level of inventiveness of the project (inventive outcomes) and the joint realisation of strategic goals (strategic outcomes).

4b The effect of increasing strategic proximity on goal achievement is negative. This is manifest in low achievement levels in regard to the project's inventive and strategic outcomes, its efficiency (operational outcomes), the personal satisfaction and learning effects (personal outcomes), as well as the establishment of a long-term, trustful relationship and/or access to other partners (relational outcomes).

Novelty creation is said to be contingent on new combinations of knowledge and skills which are more likely realised with rising levels of **technological distance**, understood as differences in the partner's knowledge bases. On the other hand, overlap in knowledge base is a direct predictor of the partner's abilities to share knowledge. Thus, increasing levels of technological distance have been suggested to hamper knowledge sharing. It has further been assumed that the difficulties might rise particularly when differing basic knowledge areas are fused with no overlap in codes and basic approaches. Furthermore, when the people involved in the co-operation project come to their limits to share knowledge, this is supposed to have a negative motivational effect, leading to irritations, impatience, disappointments and frustration. Besides, there might be hierarchies between different disciplines and the level of acceptance and respect for the other might decrease with increasing levels of technological distance. Likewise, the perceived threat in the expert status of individuals might increase. Both might lead to a resistance within the co-operation project to contribute in the best manner. From this discussion, the following propositions are drawn:

5a *The relationship between increasing technological distance and goal achievement follows an inverted U-shape relationship. Particularly the inventive potential increases with rising levels of technological distance (inventive outcomes). At the same time, higher levels of technological distance are accompanied by negative effects regarding the ability to exploit the potential (inventive outcomes), the efficiency of the project (operational outcomes) as well as the personal experience and rewards from the project (personal outcomes), which overrides the positive effects at some point.*

5b *The described effects are particularly pronounced with increasing levels of technological distance in the basic bodies of knowledge of the partners.*

While established relationships can be exhausted in their potential to generate novel combinations, **relational distance** brings about new knowledge, capabilities and ideas. However, this novelty comes at the expense of 'social capital'; i.e., at the expense of certain structural, cognitive and relational advantages which social capital conveys. Through prior experience, the partners share knowledge, codes and inter-organisational routines, which supports their ability to share knowledge and co-ordinate the contributions of the partners. Moreover, close relational ties – also indirect through third parties – increase trust and the motivation of the partners to contribute. Otherwise, the costs of establishing shared knowledge, codes, inter-organisational routines and trust need to be carried within the project. Thus, it is expected that relational proximity is beneficial up to a threshold level when its novelty potential is exploited and new relationships should be explored. Accordingly, the following proposition is developed:

6. *The relationship between increasing relational distance and goal achievement follows an inverted U-shaped relationship. In particular, relational distance has a positive effect on the level of inventiveness (inventive outcomes) as well as the strategic contribution of a project (strategic outcomes). On the other hand, relational distance has a negative impact on the efficiency of the project (operational outcomes) and personal satisfaction (personal outcomes), which levels out the positive effects at some point.*

The different dimensions of distance differ in their underlying mechanisms. Some are more closely related to knowledge and cognition, i.e, the ability to share knowledge (institutional, organisational and technological distance), while others are more related to the motivation to do so (strategic and relational distance). As co-operation in R&D is a highly knowledge-intensive process building on the sharing of tacit knowledge or know-how, it is expected that the different dimensions of distance differ in their **relative impact**: those dimensions which are directly related to knowledge and cognition are assumed to have a stronger impact on the realisation of the project's goals. Moreover, it is expected that the closer a dimension is related to the primary value-generating activity, the stronger its impact. This leads to the following proposition:

7. *The more directly a dimension is linked to knowledge and cognition – i.e., the cognitive variety induced into the project as well as the cognitive abilities of the partners to share and combine their knowledge – and the closer it is to the primary value-generating task, the stronger is its effect on inter-organisational co-operation compared to those dimensions which are less associated with shared knowledge and cognition as well as the primary value-generating activity. Stronger effects are assumed for technological, moderate effects for institutional and weaker effects for organisational distance.*

Although this disentanglement of different dimensions is important to understand the single effect of each dimension, it is likewise important to consider that there are interaction effects among them. Specifically, as the dimensions vary in their effects and have eventually opposing effect signs, they can either reinforce or compensate each other in their impact.

In particular, two dimensions have been attributed a rather **indirect effect** which implies that they exert their influence only in combination with specific constellations of other dimensions. This indirect nature has been attributed to the geographical and the relational dimension. In line with hypothesis 7, this indirect effect is supposed to be stronger for those dimensions that are directly related to the ability to share knowledge between the partners. Both propositions are formulated below:

8a *Geographic and relational distance exert an indirect effect on goal achievement, which implies that they either reinforce or mediate the direction of the isolated effects of other dimensions of distance.*

8b *The indirect effect of geographic and relational distance is particularly pronounced for those variables that are directly related to the ability of the partners to share knowledge and the primary value-generating task; i.e., in descending order from strong to weak effects for technological, institutional and organisational distance.*

Impact of intermediary variables

Furthermore, two intermediating variables have been discussed to influence the effects of different dimensions of distance.

First, the **invention stage** has been introduced as a potentially mediating variable, distinguishing between co-operative research and co-operative development activities. As research is a creative, experimental process geared at the generation of new knowledge, difficulties in knowledge sharing as well as in the co-ordination of the project are likely. Also, with less specified contracts, opportunistic risks might be higher. By contrast, development activities build on existing knowledge and are geared toward the realisation of new products, processes or services. Development is a rather systematic process where work packages can be drafted, which supports a division of labour. Furthermore, a causal understanding of key scientific or technical mechanisms is likely to exist and respective codes for knowledge sharing might be available. On the other hand, it has been suggested that development depends stronger on know-how while research comprises more know-why, the first being more difficult to share. However, the hypothesis follows the first argument and holds that:

9. *The earlier the co-operation is located in the invention process the more difficult knowledge sharing is supposed to be leading to higher negative effects of distance in any dimension on the inter-organisational co-operation project.*

Second, although inter-organisational co-operation is often paraphrased as 'interactive learning', the extent and meaning of learning within inter-organisational co-operation can vary. Indicative of this are the results of Mowery et al. (1996) who observed that 'significant inter-firm transfer of knowledge and technological capabilities occurs in only a subset of alliances' (p. 89). In this case, the partners' knowledge bases tend to converge over time, while in the other cases, co-operation builds on a division of labour with a successive divergence of knowledge bases between the partners.

10 *The more the project is oriented toward learning from the partner the more intense knowledge sharing is supposed to be leading to higher negative effects of distance in any dimension on the inter-organisational co-operation project.*

Conclusions for management

However, firms can organise proximity and actively leverage the potential or at least mediate the negative effects of distance. Thus, the final set of hypotheses turns to the organisation of inter-organisational co-operation projects. While the prior propositions have turned to the challenges posed by different forms of distance, this paragraph considers the remaining variance in different performance levels of inter-organisational projects, which can be traced back to different organisational responses to these challenges.

11. *The effect of distance in different dimensions on goal achievement, as well as the inventive, strategic, operational, personal and relational outcomes, is mediated by the way management achieves a requisite level of proximity in all dimensions within the project.*

It is further assumed that the organisational challenges vary with the characteristics of the intermediating variables.

12a *As the effects of distance in different dimensions are supposed to vary with the stage of the co-operation project in the invention process, so will the management responses to address the respective challenges.*
12b *As the effects of distance in different dimensions are supposed to vary with the learning rationale of the co-operation project, so will the management responses to address the respective challenges.*

These hypotheses are tested empirically with SMEs from the German biotechnology industry, which is introduced in the subsequent chapter (Chapter 7).

6 Research Setting: Biotechnology Firms in Germany

Industries differ in regard to their structure, the role and dynamics of the science base, the meaning and locus of R&D, invention and innovation activities, the importance of the local industrial and scientific base compared to global knowledge value chains and so forth (e.g., Carlsson & Stankiewicz, 1991; Pavitt, 1984). Accordingly, they also differ in regard to the firms' strategies toward inter-organisational co-operation in R&D, the benefits they expect from it, the reach of their partner networks and the respective challenges associated with inter-organisational co-operation.

In order to come to meaningful comparisons, results and recommendations, the empirical investigation of this thesis is limited to one industry and one country: the German biotechnology industry. The following factors have been considered in the selection of the German biotechnology industry as research setting:[1]

- an industrial structure characterised by many small and medium sized firms who are the central carriers of invention in this industry;

- a heavy dependence of the firms on a rapidly moving global science and technical frontier and thus on constant R&D and innovation activities (biotechnology as a 'science-based business');

- the breadth of the knowledge bases and diversity of techniques and technologies needed to affect R&D and commercialise biotechnology innovations;[2]

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[1] Fernández-Ribas and Shapira (2009) identify central factors which influence the existence and degree of international co-operation, which have been taken into account: (i) the strength of the home country in regard to domestic science, technology and innovation capabilities; (ii) characteristics of knowledge generation and exchanges; (iii) technological opportunities and industry characteristics; (iv) perceived advantages of international co-operation and (v) other enterprise characteristics, such as firm size.

[2] Biotechnology knowledge and techniques are a central part of the observed fusion or convergence of different technologies (e.g., Shmulewitz et al., 2006; Nordmann, 2004; Rocco et al., 2000; Kodama, 1992).

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- a risky, costly and protracted R&D process;
- a highly distributed nature of inventive and innovative activities with a large number of inter-organisational co-operation agreements;
- a global distribution of biotechnology value chains, and a topography of ‘local nodes and global networks’;
- Germany’s position as one of the forefront biotechnology nations; however, the lead is still found in the US and UK; while new countries – particularly from the BRIC states – enter the biotechnology business.

These characteristics of the German biotechnology industry are outlined in detail in the following paragraphs. The outline starts with a definition of modern biotechnology, followed by a description of its knowledge base, industrial structure and division of innovative labour. The fourth part offers a comparative analysis of national strengths in biotechnology and discusses the geographic organisation of the biotechnology industry. Finally, key figures and structures of the German biotechnology industry are presented.

Definition and Applications

The OECD defines **biotechnology** as ‘the application of science and technology to living organisms as well as plants, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services’ (OECD, 2005a).

Often, the auxiliary **‘modern’ biotechnology** is used to delineate current biotechnological from traditional methods and applications, such as the use of yeast and bacteria for food processing. These traditional methods aimed at systematically controlling and altering the environments of usually large colonies of bacteria to induce them to multiply in large quantities (e.g., in processes of fermentation and cell culture). Modern biotechnology, by contrast, builds on techniques involving recombinant DNA and cell fusion, allowing scientists to manipulate the inner structures of micro-organisms in order to alter their behaviour or functionality.

The broad definition of biotechnology as presented above encompasses modern biotechnology, but also many traditional or borderline activities (OECD, 2005a). To delineate 'modern' biotechnology in its narrow sense, the broad definition is accompanied by a list-based definition which encompasses specific techniques as applied in modern approaches (table 6.1).

The OECD (2005a, p. 10) further defines a **biotechnology active firm** as 'a firm engaged in key biotechnology activities such as the application of at least one biotechnology technique (as defined above) to produce goods or services and/or the performance of biotechnology R&D'. A **dedicated biotechnology firm (DBF)** is more narrowly defined as 'a biotechnology active firm whose **predominant** activity involves the application of biotechnology techniques to produce goods or services and/or the performance of biotechnology R&D'. These firms are the target population of the empirical investigation.

It stands out that modern biotechnology is defined and characterised by its methods without any reference to a particular sector or application. The reason lies in the breadth of potential applications of biotechnology in various sectors, such as pharmaceuticals, medical devices, food, agriculture, chemistry, forestry, environment and instruments and equipment (Brink et al., 2004). This broad potential range of applications of biotechnology knowledge and techniques has led to a predominant view of biotechnology as constituting a 'general purpose technology' (Helpman, 1998) rather than a sector (Brink et al., 2004).[3] However, there exists now a large firm base which can be clearly assigned to modern biotechnology based on its scientific and technical abilities and activities; some of which serving more than one traditional sector. It is expected that these firms share more characteristics, such as their prime knowledge base and innovation dynamics, than some firm populations under the umbrella of one sector do. In the following, the term biotechnology industry is used to refer to the population of dedicated biotechnology firms.

[3] Laage-Hellman et al. (2004) suggest that modern biotechnology 'is both a broad emerging technological area and a specific economic activity' (p. 3). However, the conceptual discussion of modern biotechnology as a technology or sector is rather of interest when deciding on the statistical measurement than for the purpose to tailor a population of firms which share some basic characteristics and environments in order to reduce the heterogeneity in external variables which influence the research model.

Table 6.1: List-based Definition of Modern Biotechnology (OECD, 2005a, p. 9)

DNA/RNA	Genomics, pharmacogenomics, gene probes, genetic engineering, DNA/RNA sequencing/synthesis/amplification, gene expression profiling, and use of antisense technology.
Proteins and other molecules	Sequencing/synthesis/engineering of proteins and peptides (including large molecule hormones); improved delivery methods for large molecule drugs; proteomics, protein isolation and purification, signalling, identification of cell receptors.
Cell and tissue culture and engineering	Cell/tissue culture, tissue engineering (including tissue scaffolds and biomedical engineering), cellular fusion, vaccine/immune stimulants, embryo manipulation.
Process biotechnology techniques	Fermentation using bioreactors, bioprocessing, bioleaching, biopulping, biobleaching, biodesulphurisation, bioremediation, biofiltration and phytoremediation.
Gene and RNA vectors	Gene therapy, viral vectors.
Bioinformatics	Construction of databases on genomes, protein sequences; modelling complex biological processes, including systems biology.
Nanobiotechnology	Applies the tools and processes of nano/microfabrication to build devices for studying biosystems and applications in drug delivery, diagnostics, etc.

Biotechnology Knowledge Base, Industrial Structure and the Division of Innovative Labour

Modern biotechnology initially centered on a rather new knowledge base which was developed in the realm of science; i.e., mainly in universities and research institutes (Brink et al., 2004). Hence, biotechnology is a fundamentally 'science-based business', characterised by 'entities that both participate in the creation and advancement of science and attempt to capture financial returns from this participation' (Pisano, 2010, p. 471).

Moreover, biotechnology is a very dynamic and interdisciplinary business. Its knowledge base displays continuous progression which leads to a permanently shifting global science and technological frontier. At the same time, a large number of disciplines, technologies and skills need to be mobilised in order to proceed from the initial idea to an end product, process or service. These are not only various sub-disciplines of biotechnology (molecular biology, immunology, cell biology, computational chemistry, genetics, etc.) but also medical and chemical knowledge, informatics and engineering skills among others. Particularly at the front end of scientific development – such as in systems biology, genomics, proteomics, and nanobiotechnolgy – many disciplines and technologies intervene. Hence, Pisano (2010, p. 473) outlines three fundamental problems, biotechnology business is subject to: a 'learning problem', an 'integration problem' and a 'risk management problem'.

First, due to the high dynamism of biotechnology, the firms are confronted with the need to constantly learn and update their knowledge base to remain competitive ('learning problem'). Second, they face an 'integration problem' to combine and integrate knowledge across diverse knowledge and disciplinary boundaries. Pisano assumes that the integration problem is even more complex in biotechnology compared to other science-based or high-technology industries, due to the relative immaturity of the knowledge base. He argues that in areas which are characterised by more mature knowledge bases, knowledge tends to be modular, which allows for a division of labour. In biotechnology, however, the boundaries tend to be less well defined and modular, and knowledge is highly tied to individuals or the close confines of a research laboratory, which demands for a closer integration compared to other areas of research.[4] While some of the accumulated knowledge are formalised in procedures

[4] Likewise, Senker (1995) assumes that 'genetic engineering techniques continue to incorporate many empirical and tacit elements; even in the more codified microbial systems, it is not

and methods, large parts remain a tacit art. As a consequence, Pisano assumes that sharing experiences over an extended period of joint work matters to develop shared cognition, knowledge and interpretation. Third, Pisano outlines a 'risk management problem' which first of all comprises the risk of the basic technological feasibility of the scientific ideas; which again differs from other high-technology industries where the fundamental scientific or technical feasibility is usually not at stake. Consequently, biotechnology R&D is a highly risky, unpredictable, iterative, protracted and costly activity (Pisano, 2010; DiMasi et al., 2003). In this sense, DBFs fulfill important intermediary roles, translating scientific discoveries into commercial products, processes and services. According to Pisano (2010), these firms tend to 'keep one foot in the world of academia and another in the world of business' (S. 473).

Accordingly, the commercialisation of biotechnology was from the beginning mainly the endeavour of small entrepreneurial start-up firms which stemmed to a large part from universities or other research institutes. Particularly the 1980s and 1990s were marked by an upsurge of new firm foundations worldwide.[5] Only later, larger, incumbent firms – most notably from the pharmaceutical industry – entered the business. Initially, they functioned primarily as development and commercial partners to conduct large scale clinical studies and to refer to their established global distribution networks to commercially exploit the new products, processes and services.

The pharmaceutical industry was then in need to increase the efficiency and productivity of the drug development process, which urged the firms to explore and exploit new possibilities early on (Laage-Hellman et al., 2004). Modern biotechnology promised to close this productivity gap and has largely transformed the knowledge base in the pharmaceutical industry; broadening its knowledge and technological base. The biotechnology knowledge base is based primarily on knowledge in the fields of molecular biology and immunology, whereas the classical pharmaceutical knowledge base was based on organic chemistry and medicine. Also in

always possible to specify precisely which gene fragment will be spliced or, where this is possible, to explain why a particular set of procedures produces a specific effect' (p. 430).

[5] Genentech, which was founded in California in 1976, is usually referred to as the first modern biotechnology firm. Genentech introduced and advanced recombinant DNA technology in order to genetically modify living organisms to produce human insulin. In 1982, this first biotechnologically produced drug was introduced into the market by Genentech's commercial partner Eli Lilly (Patzelt & Brenner, 2008). This success model marked the beginning of the 'biotechnology revolution' (Hopkins et al., 2007; EC, 2002) as it is sometimes called and functioned as a role model for a stream of new firm foundations in the following years (Pisano, 2010, 2006).

other sectors, a similar expansion or differentiation of the knowledge base to incorporate biotechnology knowledge and techniques took place. These include medical technology, agriculture, food, chemistry, forestry, pulp and paper, environment, and instruments and equipment (Brink et al., 2004). However, these industries face less pressure and the pace of adopting and exploiting biotechnological knowledge is correspondingly lower.

As a response to the high knowledge dynamics, broad knowledge needs and high investments and risks, a vertical and horizontal division of labour between different organisations has emerged (Powell & Brantley, 1992). Despite the fact that over the years large pharmaceutical players have become more central in biotechnological research networks, this division of labour has remained largely unchanged (Saviotti & Catherine, 2008; Roijakkers & Hagedoorn, 2006).[6] Large and small players benefit likewise from this sharing of innovative labour: small firms can realise their scientific goals, being able to rely in the case of success on a large partner who has the resources for development and market introduction. Large players are not threatened in their existence by these players but can observe new scientific developments and invest in these when their risks and benefits are largely predictable.

Thus, despite some consolidation activities with a number of take-overs in the last decade and the continuous adoption and incorporation of biotechnology methods inside large incumbent firms, the ‘dynamic complementarities’ (Rothwell & Dodgson, 1994) between small and large firms persist. There is a constant emergence of new players, building their business model on new scientific discoveries or commercial niches. In particular due to the constant development of new biotechnology knowledge and the fast pace of these developments, Pyka and Saviotti (2005) as well as Saviotti and Catherine (2008) expect this distributed and network organisation of the industry to prevail.

Another specificity of the industry, which reinforces the distributed nature and supports the success of small firms is the extensive reliance on the patent system to protect key knowledge (Blind et al., 2006). According to Pisano (2010), this circumstance significantly enables firms with complementary capabilities to access their mutual knowledge.

[6] This situation is still unchanged and the number of biotechnology-pharma deals is still increasing. The 2008 global biotechnology report from Ernst & Young noted that ‘to shore up their revenues, pharmaceutical companies are turning to alliances and acquisitions as never before’ (Ernst & Young, 2008, p. 22).

These dynamics, diverse skills and complementarities have led to many collaborative ties and networks among universities, other public research organisations, dedicated biotechnology firms and large multinational firms as well as among dedicated biotechnology firms. Modern biotechnology is characterised by a high rate of formation and dissolution of co-operative ties (Powell et al., 2005, 1996). For this reason, the industry is exemplary for a 'distributed' or 'open' innovation process where many different actors contribute to advance new ideas and techniques. Involved are firms, universities, other public and private research organisations, patient organisations, governmental bodies and so forth. Innovative linkages are found as much vertically along the value chain as horizontally to generate a requisite variety for inventive or innovative combinations.

Due to its distributed innovation processes, biotechnology has attracted considerable scholarly attention, particularly from the fields of innovation and organisational science. Thus, many network studies have emerged which aim to explain the joint innovation efforts in biotechnology and which demonstrate the extent and meaning of inter-organisational collaboration, particularly for innovation (e.g., Whittington et al., 2009; Roijakkers & Hagedoorn, 2006; Gay & Dousset, 2005; Owen-Smith & Powell, 2004; Walker et al., 1997; Powell et al., 1996; Shan et al., 1994).

While many studies on inter-organisational co-operation and networks in the biotechnology industry adopt a very positive and optimistic stance as to their contribution, some newer contributions point to the eventual neutral or even negative effects of inter-organisational co-operation. For Sytch and Bubenzer (2008), network ties may also turn into liabilities, for example by turning out to be competitive rather than co-operative, distracting too much resources and energy which is missing elsewhere in the firm, leading to resource lock-ins in unproductive relationships, or over stretching the managerial capacity of the firm. For these reasons, they suggest that the burdens may eventually outweigh the benefits of inter-organisational co-operation which put strain on the firm's R&D and innovation efforts.

This new critical stance regarding the benefits of inter-organisational co-operation together with the increasing drivers to engage in co-operation at a global level calls for a detailed analysis of constellations which promise to be more successful or rewarding than others. This knowledge serves to guide the firms' awareness, support their decision-making and suggest ways to manage the challenges.

National Strengths and the Geographic Organisation of the Biotechnology Industry

Initially, the commercialisation of biotechnology was mainly carried by US players (Laage-Hellman et al., 2004). Subsequently, it spread from the US to other countries, fueled by private and public initiatives (Enzing et al., 2007). In 2007, approximately 4,700 dedicated biotechnology firms existed worldwide, of which close to 780 firms were publicly traded (Ernst & Young, 2009, see table 6.2). These firms generated more than 89 billion US$ revenues, spent close to 32 billion US$ on R&D and employed more than 200,000 people. Although Europe started with a time lag compared to the US, it hosted the majority of firms in 2007 (39%). 37% of the firms were located in the US, followed by 16% in the Asian Pacific region and 8% in Canada. However, US firms were much larger employing on average 73 employees, whereas European firms only employed 27 people on average. Also in regard to their financial performance, US firms incurred considerably higher revenues and also spent more money for R&D activities. In this respect, Cooke (2006) noted that Europe 'has exploration knowledge capabilities, [whereas] the most highly developed exploitation knowledge capabilities are concentrated in U.S. bioscience metacentres' (p. 35).

Table 6.2: The Structure of the Global Biotechnology Industry in 2007 (Ernst & Young, 2009, p. 22)

	Global	**US**	**Europe**	**Canada**	**Asia Pacific**
Number of companies					
Public companies	776	371	178	72	155
Public and private companies	4,717	1,754	1,836	358	769
Share of all companies (in %)	*100*	*37*	*39*	*8*	*16*
Public company data					
Revenues (US$m)	89,648	66,127	16,515	2,041	4,965
R&D expense (US$m)	31,745	25,270	5,171	703	601
Net income (loss) (US$m)	(1,443)	417	(702)	(1,143)	(14)
Number of employees	200,760	128,200	49,060	7,970	15,530

Considering the global map of biotechnology research, development and commercialisation, it strikes that the distribution of firms is not even across the globe. It is concentrated in a few large global bioregions, followed by smaller regional agglomerations. The largest bioregions are found in the US; in the areas around Boston, New York, the San Francisco Bay Area and San Diego (Cooke, 2008). These regions are characterised by a high number of different actors on the spot. According to Cooke, the size of these regions gives way to a 'related variety' which is conducive to generate innovation. In these regions, 'the evolutionary stimulus is supplied by the attraction of a variety of imitative and innovative *talent* to the region, a Schumpeterian "swarming" realising increasing returns to *related variety* where innovation may move swiftly through various parts of the innovation "platform" ' (p. 14, italics in the original). Within Europe, the pattern of regional clusters is more diverse with many smaller agglomerations, such as those around Cambridge and Oxford, Munich, Stockholm-Uppsala and the Medicon Valley. Due to size disadvantages, it is concurrently claimed that these regions are to a larger extent dependent on external, non-local sources of ideas and resources in order to achieve a requisite productive variety (Caspar & Murray, 2004).

Parallel, new bio-regions – particularly in Eastern Europe, Russia, Singapore, Israel, India and China – emerge, which shift the global distribution of biotechnology activities. Especially India and China are seen as two key biologics supplier countries in the future (Cooke, 2008). Besides, these countries also establish state-of-the-art capabilities in research and development; fusing traditional approaches with modern biotechnology. As the market and hence the competition in biotechnology are global, this greater country scope urges firms, also from established regions, to link up internationally; i.e., to monitor and leverage biotechnology knowledge at remote locations and from different institutional settings.

Analogously, researchers from Europe and Canada report higher incidences of national and international co-operation in recent years (Belussi et al., 2010; Dahlander & McKelvey, 2005; Coenen et al., 2004; McKelvey, 2004; Gertler & Levitte, 2003; Zeller, 2001). For example, McKelvey (2004) found for those firms of the Gothenburg biotechnology region that are active in formal collaboration a share of 63% of agreements with global partners. For a sample of German biotechnology firms, Zeller (2001) reports that the spatial concentration in a biotechnology cluster does not necessarily imply a close network of input–output relations among the actors. By contrast, knowledge and technology transfer often happens on an international, mostly North Atlantic, scale. This is likewise reported for the Canadian biotechnology sector for which Gertler and Levitte (2003) find a similar local–global pattern of relationships and observe a growing importance of non-local relationships.[7] Thus, the biotechnology industry is currently perceived as exemplary for a 'local–global' pattern of innovative interaction (Coenen et al., 2004).

Modern Biotechnology in Germany

The development of the German biotechnology industry started off in the early 1990s. The ignition for the foundation of the first biotechnology start-ups was the amendment of the German Genetic Engineering Act in 1993 together with the first governmental programme to foster biotechnology activities in Germany: the *BioRegio* competition which was launched by the German Ministry for Education and Research in 1995 prompted many, foremost university, researchers to invest in spin-offs which led to a number of biotechnology clusters within Germany. This cluster campaign was followed up by a second cluster competition called *BioProfile* that was launched in 1999 by the same ministry and served to complement and strengthen the clusters which were born out of the first initiative (Dohse & Staehler, 2008; BMBF, 2005). These public programmes contributed to a rise of firm foundations in Germany (Dohse & Staehler, 2008). Meanwhile, Germany upholds a leading position within Europe; contested only by a strong biotechnology firm base in the UK (Dohse & Staehler, 2008).

Biocom AG, an information service on the German biotechnology market, regularly monitors Germany's biotechnology industry and publishes data on its firms. Central performance figures of its latest 2010-report are presented in table 6.3. For 2009, Biocom AG registered a total number of 531 dedicated biotechnology firms in Germany, of which the majority was active in R&D (454 firms). These firms together employed 14,950 people and achieved a turnover of EUR 2.18 bn. Nearly half of this sum, EUR 1.05 bn, was reinvested in R&D. This ratio of up to 50% demonstrates the high R&D intensity of the firms.

[7] For Cooke (2008), this weight of global partners reflects the relative thinness of the pharmaceutical and biotechnology market there. This argument is in line with the statement that a threshold level of 'related variety' needs to be present for firms to find partners within their immediate environment. In the absence of this threshold level, he suggests that firms are urged to expand their geographic scope of activities.

Table 6.3: The German Biotechnology Industry in 2009 (Biocom, 2010, p. 5)

Indicator	Value
Number of dedicated biotechnology companies	531
Number of dedicated biotechnology companies active in R&D	454*
Number of employees in dedicated biotechnology companies	14,950
Turnover of dedicated biotechnology companies	EUR 2.18 bn
R&D expenditure of dedicated biotechnology companies	EUR 1.05 bn

* taken from Biocom online database, www.biotechnologie.de (18.02.2010)

Figure 6.1 offers additional data on the firms, their size distribution, areas of activities, regional distribution and co-operation activity. In figure 6.1a, the size distribution of the dedicated biotechnology firms is presented. It demonstrates the small to medium-sized structure of the industry. In 2009, nearly 96% of the firms employed less than 249 employees, of which 45% employed less than ten, a comparable share of 42% between ten and 49 people, 7% up to 100 and only 4% between 100 and 249 people. Figure 6.1b presents their main areas of activity. It shows the high concentration of the firms in the area of health or medicine, including animal health (45%). This is followed by 36% of the firms who indicated their main activity in the field of non-specific services. Only 10% of the firms operated in the area of industrial biotechnology, 5% in agricultural biotechnology and another 4% were active in bioinformatics.[8] Figure 6.1c presents a map of the geographical distribution of the firms within Germany. It shows some regional concentrations of firms in Bavaria around Munich, in Berlin-Brandenburg, in North Rhine-Westphalia around Cologne, in Hessen around Frankfurt and in Baden-Württemberg, mainly around Heidelberg. However, it also demonstrates the broad geographic dispersion of the firms with the existence of a number of smaller clusters as well as firms which are located outside them. Lastly, figure 6.1d presents data on the co-operation activities of the firms. It includes formal agreements in the fields of research, development, validation and sales with different partners (research institutes, biotechnology companies, industrial players and other organisations). The data displays the high overall number of co-operative agreements in the industry: The 220 companies which participated in this part of the survey undertook slightly more than 2,000 co-operative agreements in 2009. The largest share of these (937 agreements) were completed with research

[8] Due to this distribution, reference is often made to specifics of the pharmaceutical industry, although none of the other areas is excluded from the sample.

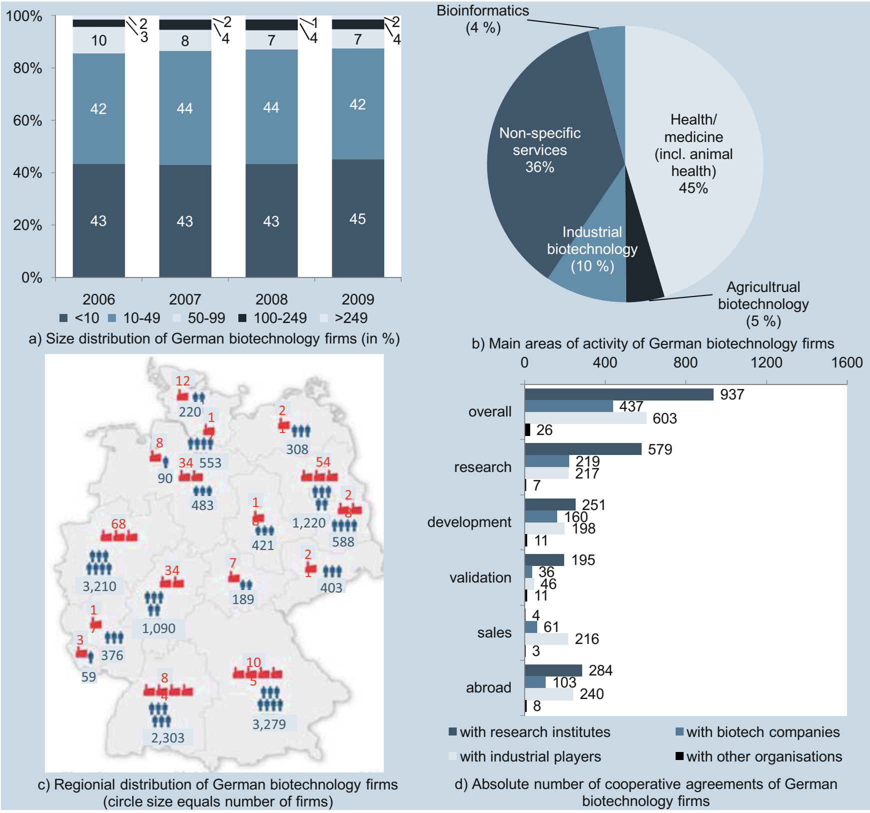

Figure 6.1: Key Characteristics of German Biotechnology Firms (Biocom, 2010)

institutes, followed by industrial players (603 agreements), other biotechnology companies (437 agreements) and other organisations (26 agreements). A large share of these co-operation agreements, namely 82% or 1,642 agreements, were closed in research and development. Again, agreements with research institutes took the lead, followed by agreements with industrial players, other biotechnology firms and other organisations. This high amount of inter-organisational co-operation in R&D demonstrates the need of the firms to frequently leverage external knowledge, resources and skills.

A similar finding has been made in an earlier survey among 127 dedicated biotechnology firms by Gaisser et al. (2005). The survey revealed that the firms had on average six co-operation partners. However, the distribution of the partners was askew with the number of partners increasing with the size of the firms. Thus, the small fraction of firms with more than 500 employees had on average more than ten co-operation agreements, while small firms had significantly less. The average duration of the agreements was between 2.5 and 3 years. Regarding the composition of the partner types, the above results were confirmed in that public research organisations turned out to be the most important co-operation partners (52% of the partners), followed by other biotechnology firms (30% of all partners) and large enterprises, which accounted for 16% of all partners. Thus, in the study by Gaisser et al. (2005), other biotechnology companies played a greater role as co-operation partners, while agreements with large firms were less prevalent.

Moreover, for the first time, the 2010 survey by Biocom distinguished furthermore between foreign and domestic co-operation. Overall, the 220 companies which participated in the survey engaged in a number of 635 agreements with research organisations, dedicated biotechnology firms, industrial partners and other organisations abroad. This number corresponds to a share of 32% of all co-operative agreements in 2009. This finding corroborates the finding by Gaisser et al. (2005) who suggest that around one third of the co-operation partners were international, with US partners taking the lead, followed by UK and, with a larger gap, by Suisse, French, Dutch, Austrian and Japanese partners. Caspar and Murray (2004) came to similar results. From an analysis of 357 publications published by ten Munich-based biotechnology firms, they found that 33% of these were co-published with foreign partners. From this data, Caspar and Murray conclude that ‘geographic proximity is not a strong driver of collaborations’ (p. 337). Contrarily, Cooke (2008) concludes from co-publication and qualitative data analysis that German firms display only low levels of international interaction as compared to other countries, particularly compared to the UK biotechnology scene. He conforms with Caspar and Murray’s (2004) claim that ‘this suggests that firms do and possibly should broaden their scope of collaboration in order to successfully access key scientific knowledge that may not be locally available, particularly within smaller clusters whose breadth of local expertise is limited’ (p. 338).

It can be assumed that particularly in Germany, where a requisite ‘related variety’ (Cooke, 2008, p. 14) needed for invention and innovation is often not in place locally or regionally, firms are forced to expand their geographic scope to integrate geographically distant partners. Hence, the firms might be faced with the need to think and act globally at some stages of their development.

Also new policy initiatives are indicative of an increased need of European SMEs to link up internationally. In 2004, the *EUROTRANS-BIO initiative* has been implemented to foster transnational R&D co-operation of mainly SMEs from the European biotechnology sector: 'The EUROTRANS-BIO initiative (ETB) stems from the will of European member states and regions to work together in order to support trans-national R&D private/private and private/public co-operations between companies, especially SMEs, and academic labs by coordinating their national or regional public funding programs. Thus, the goal of *EUROTRANS-BIO* is to foster economic and academic biotech players in sharing risks, costs and skills related to innovation in order to develop in a more efficient way new products and technologies that could reach the market in the short/medium term.' (EuroTrans-Bio 2009). Another initiative, *TransBio*, launched in 2006, is a comparable two year international partnership initiative linking European and North American life sciences firms. According to its mission statement, the *TransBio* initiative serves 'to foster the co-operation and collaboration between European and North American biotechnology enterprises, favouring economic development opportunities and the cohesion of the global biotechnology market. Its main purpose is to foster the technology transfer from European companies and research institutes to their US and Canadian counterparts and vice versa' (TransBio 2009). Its objectives are to offer 'a new technology transfer bridge between Europe and North America in the biotechnology sector. It will stimulate technology transfer and collaborative innovation activities to enable European companies (in particular SMEs) and entrepreneurial researchers to begin the process of creating new products and services for the North American market with local partners and vice versa. The European and North American partners will benefit from new technology agreements and valuable knowledge and experience in and from the European, U.S. and Canadian markets.' Also the German biotechnology association *BIO Deutschland* has launched a working group to support German–US collaboration by exchanging experiences and establishing contacts (BIO-Deutschland, 2010). Besides, there is a number of partnering events with Eastern European and East Asian partners which serve to stimulate international co-operation. These initiatives which aim to integrate European biotechnology SMEs into global knowledge chains and commercialisation activities are indicative of the increased need to link up globally.

7 Methodology: A Retroductive Approach

This chapter outlines the methodology for the empirical investigation, taking the research purpose as point of departure. Correspondingly, the purpose of the research and the basic research perspective are outlined first. The research strategy follows a mixed method approach which is described next. This is followed by a description of the method for data collection (research instrument) and data analysis and presentation. Issues of quality (validity, reliability) of the data and methods of analysis are likewise addressed.

Purpose and Research Perspective

The purpose of the empirical part of the thesis is to investigate the impact, relative importance and interplay of different forms of distance for learning and novelty generation in inter-organisational projects, as well as to identify organisational responses to leverage the potential and counter eventual liabilities. Thus, the analysis is framed by the taxonomy of distances defined and discussed in the theoretical part and aims to develop a profound understanding of each dimension by exploring their effects, interplay and organisational responses from the perspective of the firms.

Accordingly, the research perspective follows a **retroductive approach** which combines elements from deductive and inductive research (Downward & Mearman, 2007; Tashakkori & Teddlie, 2003; Sæther, 1998; Ragin, 1994). This research perspective pursues a pragmatic view on social sciences which is best suited to address the nature of inquiry.[1] Describing retroductive research, Ragin (1994) highlights the interplay of theory and data as central process in empirical research:

> 'social research, in simplest terms, involves a dialogue between **ideas** and **evidence**. Ideas help social researchers use evidence to extend,

[1] In the philosophy of social science research, the two pole positions of either positivism or constructivism exist, which are based on different ontological and epistemological positions. Each follows different logics and demands different research methods. Pragmatism is a middle position which argues that the choice of methodology must be seen in relation to the purpose of the research (Downward & Mearman, 2007; Tashakkori & Teddlie, 2003).

J. Hartig, *Learning and Innovation @ a Distance,*
DOI 10.1007/978-3-8349-6904-0_7,

> revise and test ideas. The end result of this dialogue is a representation of social life – evidence that has been shaped and reshaped by ideas, presented along with the thinking that guided the construction of the representation' (p. 55, emphasis in the original).

The general procedure of retroductive research according to Ragin is visualised in figure 7.1.

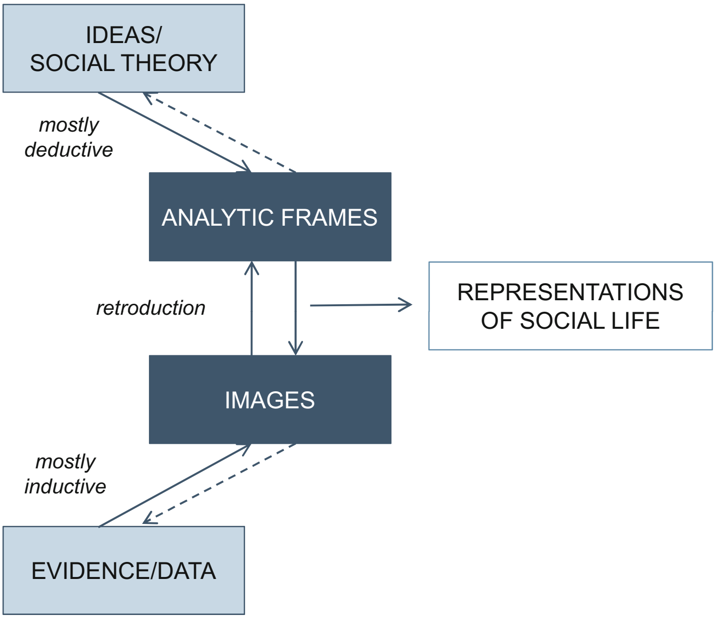

Figure 7.1: A Simple Model of Social Research (Ragin, 1994, p. 57)

It centres on four building blocks: ideas; analytic frames; evidence and images. According to Ragin, deriving adequate representations of social life proceeds through a recursive process, consisting of three analysis loops. First, an analytic frame is developed from initial ideas and theory. An analytic frame represents an articulated idea about the phenomenon under study and is made up of concepts and their relations. These are developed in a primarily deductive research process. The second loop consists of the derivation of images from empirical evidence. According to Ragin, this process is mainly inductive. The main retroduction loop finally occurs through the interaction between analytic frames and images in the phase of interpretation. This retroductive interplay yields both, 'progressively refined images of social life [as well as] better-specified analytic frames' (p. 59). Through this procedure, the analytic frame can be confirmed, refuted or amended and a coherent representation of social life is created.

Ragin acknowledges that the interplay between analytic frames and images can be more subtle and implicit or overt and explicit in social science research. In this thesis, the interplay is made an explicit and conscious part of the study: the analysis is structured by the analytic frame of different forms of distance and aims to explore their effects, interplay and organisational responses in-depth.

Research Strategy

One commonly distinguishes between three research strategies: quantitative, qualitative and mixed method research (DeCuir-Gunby, 2008; Creswell, 2003, table 7.1).

Quantitative research builds on a positivist view on social science research and is typically directed at theory verification (deductive inquiries). Correspondingly, quantitative studies that build on closed-ended questions to collect primarily numeric data are used. These usually highly data intensive investigations allow statistic evaluations to test hypotheses or make inferences to an overall population (generalisability). A typical drawback of usually closed-ended questions in broad surveys is that more in-depth information is not raised and that the researcher's conceptualisation may deviate from the participants' understanding. However, these deviations typically remain unnoticed. Hence, difficult or complex questions or emerging constructs are less suited to be included in the analysis.

By contrast, **qualitative research** follows a constructivist perspective which is useful to explore concepts or generate theory (inductive inquiries). Narrative or observational data is usually collected with the advantage that the participant uses

Table 7.1: Comparison of Different Research Designs: Qualitative, Quantitative and Mixed Methods Research (adapted from DeCuir-Gunby, 2008, pp. 125-126 and Creswell, 2003, p. 19)

	Quantitative Research	Qualitative Research	Mixed Method Research
Philosophic view	Positivist (deductive)	Constructivist (inductive)	Pragmatic (both deductive and inductive)
Methods	Closed-ended questions, predetermined approaches, numeric data	Open-ended questions, emerging approaches, text or image data	Both open- and closed-ended questions, both emerging and predetermined approaches, both quantitative and qualitative data and analysis
Advantages	Generalisability	Useful in exploring in-depth cases	Ability to generate and test theory
	Data intensive	Reflects participant's understanding	Capability to answer complex research questions
			Possibility of corroborating findings
Disadvantages	Lack of in-depth information	No generalisability	Time consuming research design, data collection and analysis
	Researcher's conceptualisation may not reflect participants' understanding or experience of the constructs		Need for knowledge of multiple methods

his own language or operates in his natural environment. Critical concepts can be discussed with the interviewee, feedback loops and explanations are possible so that mutual understanding is the greatest. Thus, complex or emerging research topics are usually addressed via qualitative research designs. However, to base cause- and effect relationships which are generalisable is less common (Yin, 2003).

A **mixed method research** approach combines elements from quantitative and qualitative research (DeCuir-Gunby, 2008; Teddlie & Tashakkori, 2003a; Creswell, 2003, 1999). It is best suited when following a pragmatic perspective in social science research. Building on both quantitative and qualitative data, it integrates the possibility to explain and explore (Creswell, 2003; Teddlie & Tashakkori, 2003a). Depending on the actual study design, it can be used to generate theory, test theory or both. Hence, a combination of approaches allows best to answer complex research questions and permits to triangulate or corroborate findings within a single study (Creswell, 1999).[2] It is used to expand an understanding from one method to another or to converge or confirm findings from different data sources (Creswell, 2003). By combining a quantitative and a qualitative strategy, the expectations from theory can be probed statistically and corroborated and explained qualitatively (Downward & Mearman, 2007). It is commonly perceived that the mixing of quantitative and qualitative methods results in the most accurate or complete depiction of a social phenomena under investigation (Creswell, 2003; Johnson & Turner, 2003). However, mixed method approaches are marked by high investments in designing the study, collecting and analysing data, as well as becoming familiar with multiple methods (DeCuir-Gunby, 2008).

Thus, the pragmatic research perspective which is adopted in the thesis allows a combination of different methods which is best suited to investigate the research questions. Thus, the twin task of probing the analytic frame of a multiplicity of forms of distance and developing images from empirical data which corroborate, refute or expand the initial theoretical assumptions, is best addressed by a mixed method approach.

[2] The term triangulation was coined by Denzin (1978) to describe study designs in which different data sources are used to study the same social phenomenon from different perspectives. In the following, Jick (1979) discussed data triangulation in terms of its potential to offset the weaknesses of one method by combining it with the strengths of another (Teddlie & Tashakkori, 2003a). Triangulation strategies represent an important predecessor of mixed method designs.

In this thesis, qualitative and quantitative data is raised concurrently and equal weight is attached to both kinds of data (figure 7.2).[3]

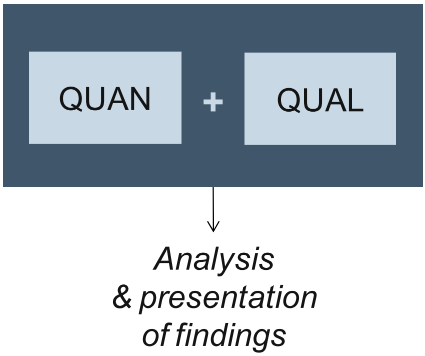

Figure 7.2: Research Strategy: Combining Quantitative and Qualitative Data

Although separate analysis steps of the quantitative and qualitative data are needed, the overall strategy is to combine quantitative and qualitative data throughout all stages of research, the collection of data, its interpretation and presentation.

Instrument for Data Collection

Generally, different instruments can be used or combined in order to raise quantitative and qualitative data in a mixed method study (Creswell, 2003). Moreover, one commonly distinguishes intramethod from intermethod mixing (Johnson & Turner, 2003). Intramethod mixing is defined as the use of a single method that includes both qualitative and quantitative components, e.g. the combination of open- and closed-ended items on a single questionnaire. Correspondingly, intermethod mixing refers to the use of two or more different methods for data collection, such as a broad questionnaire survey which is followed up by in-depth interviews.

[3] The presentation in figure 7.2 follows the standard denotation as suggested by Creswell (2003), Teddlie & Tashakkori (2003b) as well as Morse (1991).

One generally distinguishes between primary and secondary data sources (Johnson & Turner, 2003). The use of secondary data implies three criteria: the existence of secondary data, its accessibility and quality. Considering both the level of detailedness of the research questions and central characteristics of the unit of observation – SMEs – secondary data providing sufficiently detailed data were not available.[4] Thus, direct access to the unit of investigation in order to collect **primary data** has been sought. Questionnaires, interviews, focus groups, tests and observations remained as alternative instruments for data collection (Johnson & Turner, 2003). However, the lack of observability of co-operation behaviour which takes place within the confines of a firm inhibited the use of observations. Moreover, the natural environment was sought to be preserved which opposes the use of tests. Large-scale survey data would be a good alternative to collect large numbers of data, particularly for numerical evaluation. However, it was known from previous studies that the response rates to surveys are generally very low, particularly in modern biotechnology (e.g., Nusser et al., 2007).

Hence, **personal expert interviews** emerged as method of choice. Gorman and Clayton (2005) summarise the following five advantages of interviews: immediacy; mutual exploration; investigation of causation; personal contact and speed. Interviews allow to receive an immediate response to a question where both parties can explore the meanings of questions and answers, in order to resolve ambiguities. The third advantage according to Gorman and Clayton is that interviewing allows to explore causal relations; i.e., an understanding for why individuals or organisations (re)acted in certain ways can be gained. Thus, open-ended questions yield more profound insights, which is a prime aspiration of the empirical investigation. As interviews give a more personal emphasis to data collection, individuals who would be reluctant to take part in a survey study, might agree to participate. Further, personal interviews can yield data which is otherwise perceived as confidential or

[4] Initially, it has been considered to follow the research tradition of patent or citation analysis (e.g., Meder, 2008; Gilsing et al., 2008; Nooteboom et al., 2006; Wuyts et al., 2005; Jaffe et al., 1993). However, this idea has been rejected for the following reasons: the size of the firms did not offer a critical number of patents or publications to calculate technology profiles. This lack of a critical mass together with the impression that the firms don't necessarily pursue a systematic approach to publishing, raised concerns about the suitability of this indicator for the current investigation. In particular, the suitability of publication and patent data has been tested within the explorative interviews (see below) where the firms were asked to comment a list of co-operation partners and activity profiles that had been compiled from publication and patent data. Majoritarianly, the interviewees rejected that list for not including strategically important partners and for providing a distorted picture of the firm's activities and knowledge bases.

sensitive; a concern which is particularly prevalent in regard to inter-organisational co-operation. Lastly, interviews can yield a large amount of data and variables in a relatively short time period and render complete data sets. Moreover, personal interviews allow to raise both quantitative and qualitative data concurrently (intramethod mixing).

Accordingly, a **semi-structured** interview guideline has been designed that includes closed- as well as open-ended elements in order to raise numeric data for quantitative analysis and verbal data for qualitative analysis at the same time (Atteslander & Kopp, 2006; Schnell et al., 2005; Mayring, 2002).

Ragin (1987, pp. 8-9) distinguishes between two meanings of a unit of analysis, the 'unit of explanation' and the 'unit of observation'. The unit of explanation is the inter-organisational co-operation project. This unit is not observable independently and firmly embedded in the broader strategy and structure of a firm. Thus, the unit of observation represents a firm, represented through a central knowledgeable person (key informant).[5] To understand the co-operation project, a basic understanding of the firm, its business and operations needs to be established first.[6]

Correspondingly, the interview guideline is structured in two main parts (see Annex A). Part A collects general information on the firm and its strategy in terms of its product-market, R&D and co-operation strategy. Part B of the interview guideline forms the main part of the interview guideline and focuses on a specific inter-organisational co-operation project with an international partner.[7] Next to general data on the co-operation project, part B focuses on the taxonomy of distances. For this step, a number of hypotheses have been constructed. A numerical

[5] The use of a key informant strategy is sometimes criticised in co-operation research for it neglects the perspective of the partner which can yield biased insights. However, confidentiality and feasibility reasons typically prevent the collection of data from both partners. Moreover, it has been shown that single experts have a good capture of the overall situation (Dyer & Hatch, 2006; Pothukuchi et al., 2002).

[6] The structure of the interview guideline follows the one used by Ermisch (2007) which proved successful in exploring inter-organisational co-operation in a structured and insightful way.

[7] The interviewees were asked to choose one international project which 'was either recently completed, or which is in an advanced stage where you were involved in the planning, partner-selection, set-up and execution phase and for which you can assess the success of the cooperation along various outcome dimensions' (see also Ermisch, 2007). The choice of projects which have been recently completed or which are close to completion was motivated by the desire to prevent recall problems (see also Simonin, 1999).

assessment of the hypotheses is followed up by open questions collecting narrative data on the firm's perception of its impact and organisational responses. Moreover, data on the success of the project has been collected which allows for the evaluation of the co-operation project. The operationalisation of the different constructs through hypotheses is introduced in section 8.2.

Design of the Field Phase

The interview guideline was **pretested** in three interviews to increase its validity. These preliminary interviews took place in Autumn 2008. As a result of these interviews, some formulations were revised and the guideline was shortened and streamlined at some points. Moreover, two additional interviews with experts in the biotechnology field provided supplementary insight on the industry, its structure, contemporary developments and future challenges.

The interviews for the **main field phase** were conducted over an extended period of one year, starting with the first interviews in October 2008 and having the last one conducted in January 2010. They were conducted either face-to-face or on the telephone. Over this period, 36 personal semi-structured interviews were conducted with different firms. In three cases, the firms decided to answer writtenly, resulting in a number of 39 case co-operation projects in total. At this, point, a moment of saturation had been achieved when it was perceived that answers resembled each other and no more novelty was expected (Corbin & Strauss, 2008). The interviews lasted between 40 minutes and 2.5 hours, with an average of one hour and 12 minutes. They were prepared and followed up by the collection of secondary data about the firm and its co-operation activities. The interviews were recorded and transcribed. Although time-intensive, this procedure of full transcription was necessary for reasons of internal validity and reliability and to derive verbatim citations (Bortz & Doering, 1995).[8]

The empirical data was obtained from German dedicated biotechnology firms. A database of firms has been created which built on the firm registry provided by

[8] As the interviews have been conducted in German language, all citations were translated into English by the author and cross-checked by a native English speaker.

Biocom AG.[9] In addition, new firms have been added that were identified from complementary sources: journals; industry reports; internet and recommendation. However, no data on *internationally* experienced firms has been publicly available. To increase the response rate, the firms have not been addressed randomly, but a targeted, step-wise procedure to identify internationally experienced firms has been pursued. For this step, external data sources, such as online search machines, press releases, industry specific journals (e.g., *transkript*, *Nature Biotechnology*), commercial data bases, as well as co-publication and co-patent data have been evaluated.[10] Another way to identify internationally experienced firms has been a chain approach where the interviewees were asked to recommend other firms that they knew to be active in international inter-organisational projects. Although being time-intensive, this 'snowball procedure' proved beneficial to gain access to firms. Another gateway to identify and gain access to firms were industry fairs and congresses where firm representatives were directly approached.

Potential interviewees within the firms were identified from public information sources – corporate homepages, publications and the world wide web – or through recommendation. Addressed were the CEO, the CSO or the chief corporate development officer or, particularly in larger firms, R&D project managers. Considering the research topic and the size structure of the firms, these people were regarded as knowledgeable (key informants). As typical for SMEs, these people are either directly involved in all corporate and also co-operation activities and can best respond to the questions at the strategic as well as operational level. Otherwise, they are in the position to recommend or appoint other knowledgeable people from within the organisation who can respond to the questions. The final set of potential interview partners was approached personally via a tailored cover letter which was sent to them by post. This cover letter was followed up by an email reminder during the following seven days and a second one during the next month. The cover letter included a brief description of the goals of the research, the structure of the interview and the types of questions. This supported the identification of an interviewee

[9] The first list of firms was created in Summer 2008. It was continuously expanded and updated during the interview phase. The firm registry from Biocom AG can be accessed online (http://www.biotechnologie.de/BIO/Navigation/DE/Datenbank/biotechnologie-db.html).

[10] Publication data was accessed from *Web of Science* and *Scopus*, both in their online versions. Patent data was derived from the *World Intellectual Property Organization* (Wipo) database (http://www.wipo.int/portal/index.html.en). Moreover, a commercial database, *PharmaProjects*, was consulted to gain additional data on firms and their co-operation partners.

within the firm. In most of the cases, the appropriate person was reached immediately. In other cases, reference was provided to appropriate interview partners from within the firm. Particularly in larger, more diversified firms, the respective interview partner was sometimes found at the level of a R&D project manager.

All interviewees were granted anonymity. The names of the interview partners were made anonymous by assigning a random number between one and 44 to each interview partner (IP). Every quote in the following chapters is labeled as 'IPn', with n denoting the random number. However, the interviewees agreed upon the mentioning of their company names in a separate reference list; provided that no direct link is possible between their name and any information or statements in the presentation of the results. Table B.1 in Annex B gives an overview of the firms that participated in the field phase as well as the positions of the interview partners. A descriptive analysis of the firms and the case projects is presented in section 8.3.1.

Data Analysis and Presentation of Results

Two kinds of data are gained from the semi-structured interviews: numeric data from the closed-ended questions and narrative data from the open-ended questions. Thus, two separate analysis steps have followed.

First, the numeric data has been evaluated in a **quantitative analysis**. This quantitative analysis serves to identify relationships between the different dimensions of distance and the outcomes of the co-operation projects. The (relative) impact of different dimensions as well as potential indirect or interaction effects are focal. In line with prior studies on success factors in co-operation (e.g., Zollo et al., 2002; Kim & Song, 2007; Sampson, 2007), regression analysis is used in order to compute relationships between the variables. The key benefit of regression analysis over bivariate analysis is the possibility to include multiple variables simultaneously into the calculation and to calculate non-linear and interaction effects. Based on the specific format of the data, Tobit regression is the method of choice (Tobin, 1958). The technical specification and the general procedure of the Tobit model are introduced in section 8.3.2. The data package for statistical analysis was *Stata*, version 10.1.

Issues of validity and reliability of the quantitative data analysis were addressed through mainly two measures. First, the interview guideline was pretested within the exploratory interviews (see above). Second, as the interviews were conducted personally, key concepts could be discussed with the interviewees and a shared understanding could be established. Both measures increased the validity of the research. Moreover, the results were triangulated by comparing the results with the findings from the qualitative analysis. Reliability of the constructs was further increased through the use of multi-item constructs, which are introduced in section 8.2.

Second, this analysis is complemented by a **qualitative analysis** of the narrative data. The aim is to critically reflect the analytic frame as well as the results of the quantitative findings based on the interviewees' perception and to derive insights on organisational responses. Here, the development of images from empirical data is central (Ragin, 1994). To reconstruct the interviewees' view and derive images from the data, the researcher needs to avoid replicating his own assumptions and perspectives. Thus, a degree of openness and self-reflexivity of the researcher is critical in the analysis of the data (Kruse, 2008). To achieve this, a systematic way for data analysis and interpretation was sought. Taking this quest as point of departure, the development of images draws on the instruments provided by grounded theory (Corbin & Strauss, 2008, 1990). Although grounded theory is based on a different methodological perspective, it provides a coherent set of tools and procedures to systematise the analysis of qualitative data and prevent individual selectivity, subjectivity and arbitrariness of the data which is chosen to underpin, corroborate or refute the quantitative results and their interpretation. Particularly, systematic coding, the building of categories and constant comparison are tools from grounded theory, which are compatible with the generation of images from the empirical data as claimed by Ragin (1994). According to Corbin and Strauss (2008), systematic coding is a process of 'deriving and developing concepts from data' (p. 65). Concepts, which correspond to the notion of ideas by Ragin (1994), are 'words that stand for ideas contained in data. [They] are interpretations, the products of analysis' (p. 159). Concepts can be derived using the actual words of the participants, they can build on the researcher's suggestion or both. They are usually aggregated into higher-level categories. Thus, a hierarchical order of concepts and categories emerges. Constant comparison finally implies that different pieces of data are permanently compared to reveal similarities and differences. These procedures constituted the pillars of the qualitative data analysis in this thesis.

The qualitative analysis was supported through the use of a software package called *NVivo 8*, which was available from QSR international as a trial version.[11] Following the procedure as described above, the rationale for the qualitative data analysis followed a step-wise procedure of establishing coding principles, developing concepts and subsuming them under higher aggregate categories. This was done for each dimension of distance separately. In a repetitive fashion, concepts and categories belonging to each dimension of distance were developed which were close to the original wording of the interviewees. Thus, in a first round, all documents were screened for similarities and differences as well as central topics which were included and summarised in a list for each dimension. This proceeding guaranteed that no important statements were dismissed or unimportant ones were attached too much weight. In a second cycle, the whole set of documents was gone over again and text passages were coded according to this list. If revisions were necessary, the whole set of documents was revised. In a final loop, central categories, understood as meta-concepts, which emerged from the narrative data were created for each dimension of distance. *NVivo* supports this process through a hierarchical tree structure, where different hierarchies of concepts and categories can be developed and respective text passages from the documents subsumed. In the presentation of the results in section 8.3.2, the qualitative results are outlined for each dimension of distance, structured on the basis of these concepts.

One main threat to validity in qualitative data analysis and interpretation constitutes researcher bias. This includes the way the questions are posed as well as the imposition of one's own framework and expectations in the phase of data interpretation and presentation, for example by selectively presenting data which fits the researcher's existing theoretical framework and assumptions. Hence, in questioning, attention was paid to presenting the questions as neutral as possible and avoiding suggestive questioning. Furthermore, the data was recorded and transcribed verbatim, which supported accurate data analysis. Although there exists no instrument to guarantee this openness, structured procedures of data analysis help to prevent researcher bias and to remedy some of the problems (Kruse, 2008). Thus, validity and reliability issues were primarily addressed through the use of a systematic way to analyse the data. Besides, some interviewees asked for a pre-version of the evaluation in order to check and comment on the presentation and interpretation of their statements. This peer review served to secure the adequate interpretation of the data and increased the quality of the analysis (Creswell, 2003; Mayring, 2002).

[11] http://www.qsrinternational.com/

This rich material is presented in two phases: (1) an extensive phase, and (2) an intensive phase.

The **extensive, cross-case phase** integrates the whole sample of 39 case cooperative projects. The statistical analysis is core to this phase in order to derive insights on the effects of distance in different dimensions on inter-organisational co-operation, the relative weight as well as potential interaction effects between different dimensions. In this phase, the qualitative data is integrated at the interpretation stage in order to explain and triangulate the quantitative findings as well as to identify and explore into central mechanisms from the interviewees' point of view. Through this step of triangulation, the validity of the quantitative research could be warranted and it was possible to 'learn more' (Corbin & Strauss, 2008, p. 13) about the impact of distance in different dimensions within inter-organisational co-operation compared to a pure quantitative procedure (Schnell et al., 2005; Golafshani, 2003).[12]

The subsequent **intensive phase** served to provide an in-depth, detailed analysis of specific cases. This additional step was motivated by the goal to explore the process of co-operation, derive management conclusions on how to best organise proximity within a project and to analyse the role of intermediary variables. These questions could best be answered in a case study way, which allowed to explore mechanisms and tools, trace complex relationships and integrate a higher number of contextual variables. The population from which the cases were drawn was the whole sample of interviews from the first, extensive phase. A multiple case approach was chosen, which consists of the detailed presentation of three cases. Eisenhardt (1989a) advices that it 'makes sense to choose cases as extreme situations and polar types in which the process of interest is "transparently observable" ' (p. 537). Hence, the objective was pursued to select cases with the highest possible potential for meaningful conclusions. The selection criteria are presented in Chapter 9.

Methodologically, the material on the inter-organisational co-operation projects which was gained through the personal interviews was used to elaborate case reports. This material was complemented by archival data. The archival documents were web-sites of the firms and their partners, press releases published online or in journals, as well as annual reports, if available. Besides, a first version of the case studies was sent back to the firms for their review and approval. In two cases,

[12] This combination of quantitative and qualitative methods also mediates the problems expected from a relatively small sample size.

this final loop resulted in additional interviews where supplementary information has been raised. Moreover, in both cases a third person from the organisation who participated in the respective case co-operation project has been consulted to reread the case study to confirm its content, presentation and interpretation. Through this final feedback loop, gaps could be filled and misunderstandings and misrepresentations could be avoided. This step also secured the internal validity of the case studies, while the use of multiple case studies contributed to external validity (Yin, 2003). As the interviews addressed a strategically important, sensible organisational area and included perceptional data on the partner and the partner's performance, the case studies were made anonymous for confidentiality reasons. The cases are followed up by a within-case as well as cross-case analysis of similarities and differences in order to come to well-grounded conclusions on organisational responses in each of these constellations as well as the impact of intermediating variables.

8 Empirical Insights: Effects of Distance

8.1 Overview

In this chapter, the procedure and results of the extensive, cross-case study, comprising the 39 case co-operation projects, is presented. The aim is to analyse the (relative) impact and interplay of distance in different dimensions. Methodologically, the analyses combines a quantitative and a qualitative analysis (see Chapter 7). Thus, the answers to the closed-ended questions from the interviews are used for quantitative analysis. The interpretation of the results is based on the qualitative information from the open questions.[1] Through this, the results can be triangulated and the conceptual framework can be further specified and expanded.

In section 8.2, the operationalisation of key constructs for the closed-end questions is outlined. This is followed by the presentation of the empirical sample and the results of the quantitative and qualitative analysis in section 8.3. Finally, section 8.4 summarises the results. Furthermore, first conclusions are drawn on the impact of distance in different dimensions in inter-organisational co-operation projects.

8.2 Operationalisation of Constructs

This section turns to the operationalisation of two central types of variables: the different forms of distance as well as different success measures to assess the results of an inter-organisational co-operation project. It departs from the assertion that the six dimensions of distance as well as the outcomes of an inter-organisational co-operation project are not directly observable, but represent theoretical constructs (Schnell et al., 2005). Thus, they are composed of different indicators which together capture important dimensions of each theoretical construct.

[1] This methodological combination of quantitative and qualitative analysis also attenuates the problem of a relatively small sample size of 39 case co-operation projects.

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Typically, the operationalisation of constructs, i.e., the design of appropriate indicators to capture them, should either follow pre-existing and accepted systems of indicators from the literature or be derived from theoretical considerations (Schnell et al., 2005). Hence, wherever available, measurement instruments from previous studies were integrated. Wherever not available, these were constructed based on the theoretical discussion presented in Chapter 4. Further, information from the explanatory interviews was used as input in the operationalisation of the constructs.

8.2.1 Operationalising Different Forms of Distance

Proponents of 'Proximity Economics' propose that the positioning of two actors vis-à-vis each other – i.e., the degree of distance separating them – is measurable. According to Bouba-Olga and Zimmermann (2004), 'the notion of distance constitutes then a quantitative evaluation, a measure of similarity' (p. 78, own translation).[2] However, so far, empirical investigations are rare and it is currently claimed that the theoretical debate needs to be grounded within and validated through empirical evidence (Carrincazeaux et al., 2008; Bouba-Olga & Grossetti, 2005). Thus, most of the dimensions of distance have not been operationalised yet. Only few and partial contributions in which some dimensions have been operationalised are found in the literature; these will be discussed and eventually integrated in the design of the constructs.

In the following passages, the operationalisation of each of the six dimensions of distance is outlined. Each construct consists of four indicators. Whenever available, metrical scales are used for measurement. However, in most cases, the positioning of the partners was based on a subjective evaluation by the interviewees of certain statements. These were rejected or accepted on the basis of a five-point Likert-like scale with the endpoints 'strongly agree' (1) and 'strongly disagree' (5). At times, reverse scores were used in order to retain the interviewee's attention.[3] The choice of perceptual measures is justified by the perspective taken: most of the dimensions

[2] The relative positioning of the partners is analysed at the beginning of the co-operation project, before it is actually enacted. It is assumed that this initial relative positioning of the partners strongly determines potential outcomes as well as the challenges of the co-operation project. The dynamics setting off after initiation of the co-operation project are addressed under the heading 'organising proximity' in Chapter 9.

[3] Simplicity in scoring was sought by relying exclusively on five-point scales. This scale length is recommended for personal interviews (Porst, 2008).

are perceived as subjective, based on a personal judgment, experience and perception of those involved in the co-operation project. Although lacking objectivity, the individual's perception is thought to be a strong indicator of the challenges and potential difficulties within the co-operation project.[4] Some of the problems inherent in using subjective evaluations are attenuated through the use of personal interviews where indicators and constructs can be further explained and discussed with the interviewees and quantitative and qualitative results cross-validated (Sale et al., 2004).

The aggregation procedure for each construct is based on the computation of the average mean of the evaluation of the single indicators belonging to a construct. A scale analysis has been conducted prior to the aggregation of the construct. This scale analysis has been based on Cronbach's alpha to determine the internal consistency of the indicators and gauge their reliability (Reynaldo and Santos 1999).

Geographic distance has been defined as an absolute as well as a relative construct, being at the same time subject to an objective as well as a subjective evaluation (section 4.4.1). It does not only include a metrical value of the distance separating the partners, but also the time to establish face-to-face contact or get in touch with the partner, including time differences. Lastly, the perceived overall accessibility of the partner has been included (table 8.1).

Table 8.1: Indicators for the Construct Geographic Distance

Geographic distance	
1.	kilometers separating the partners (kilometric distance)
2.	travel time (from home site to partner's site)
3.	time difference (between home site to partner's site)
4.	overall evaluation of accessibility of the partner

[4] Similarly, Delerue and Simon (2009) and Dong and Glaister (2007) underscore the value of perceptual measures of institutional or cultural differences between partners as an important indicator for its effects.

The first variable, kilometric distance, is computed using the GIS co-ordinates of the cities of the partners; considering the spherical geometry of the earth. Following Sorenson and Audia (2000) as well a Whittington et al. (2009), the kilometric distance between two organisations i and j is calculated according to formula 8.1:

$$d_{ij} = C \cdot \{arccos[sin(lat_i) \cdot sin(lat_j) + cos(lat_i) \cdot cos(lat_j) \cdot cos(|long_i - long_j|)]\} \tag{8.1}$$

Latitude (lat) and longitude (long) are measured in radians and C = 6,378.388 in order to obtain kilometers as the output.

Travel time and time differences have been reported directly by the interviewees. The first three indicators have been reported in metrical values (kilometers, hours), whereas the fourth variable has been raised on an ordinal Likert-like scale with the end points 'convenient' (1) and 'difficult' (5). As these indicators were measured on different scales, a scale transformation of the values has been undertaken prior to their aggregation. This transformation followed a z-standardisation of each indicator. This standardisation allowed the aggregation of the indicators to form an aggregated index (construct value).[5] The respective value of the Cronbach's alpha of the construct 'geographic distance' is 0.90, suggesting that all the indicators are highly consistent and measure the same construct.[6]

Institutional distance has been defined as the 'rules of the game' (North, 1990, p. 3) which are defined by the formal as well as informal institutions of a country (section 4.4.2). The operationalisation of the construct follows Kostova's (1999) definition and conceptualisation of institutional distance. Kostova breaks down institutional distance into three components: regulatory; normative and cognitive. Under the regulatory component she subsumes laws and rules, which is close to North's (1990) understanding of formal institutions. The normative component in-

[5] The z-standardisation is a simple conversion of scales according to the formula:

$$z_i = \frac{x_i - \bar{x}}{s_x} \tag{8.2}$$

Through this transformation, the values of the respective distributions with different mean values and standard deviations are rendered comparable.

[6] Schnell et al. (2005) recommend an alpha value higher than 0.80 as acceptable values, admitting that in social sciences, also lower values are often accepted. Hair et al. (1995) for example recommend a level of .70 above which the Cronbach's alpha values suggest sufficient internal consistency of a scale.

cludes values and norms that guide behaviour and are close to informal institutions in the sense of North. The cognitive component is fuzzier and embraces schemes, frames, inferential sets and representations that affect the way people notice, categorise and interpret stimuli from the environment. Here, the cognitive component is again decomposed into characteristic cultural traits and habits as well as language. Language is often mentioned separately as a distinguishable feature of an institutional setting. It is an essential part of culture but not in any case unique for a specific institutional setting. Table 8.2 gives an overview of the indicators chosen to construct the dimension institutional distance and their presentation in the interview guideline.

Table 8.2: Indicators for the Construct Institutional Distance

Institutional distance	
The home country of the partner differed strongly from Germany in terms of its	
1.	... regulatory framework of the respective host country.
2.	... norms and attitudes of the partner as determined by his nationality.
3.	... culture, habits, attitudes and mentalities, equally on a national level.
4.	We experienced language differences.

The indicators were raised via subjective measures of difference on five-point Likert-like scales (1=‘strongly disagree’; 5=‘strongly agree’). With a Crohnbach’s alpha of 0.83, the indicators display high consistency in regard to the aggregate construct.

Turning to **organisational distance**, current contributions assert that actors (individuals, organisations) tend to be attracted by other actors who are similar, or homophilous, along some central social characteristics; which has also practical implications for knowledge sharing (section 4.4.3). Similarity of two organisations is found in similar ‘mental maps’ or ‘cognitive foci’ which define the organisation’s basic goals and self-perception. These are manifest in organisational ‘surface regulations’, such as similar organisational structures and modes of operation (routines, scripts), as well as organisational cultures. Based on this, the four indicators presented in table 8.3 have been designed to capture the dimension organisational distance.

Table 8.3: Indicators for the Construct Organisational Distance

Organisational distance
The partner's organisation resembled ours in regard to its
1. ... basic goals and self-perception (basic logics)
2. ... organisational (administrative) structure
3. ... mode of operation (work practices, routines, 'typical' approaches)
4. ... organisational culture, commitment and motivation (goals, incentives)

Again, five point Likert-like scales with the end points 'strongly disagree' (1) and 'strongly agree' (5) have been presented to the interviewees to raise data on their subjective evaluation of similarity between the partners. The results were then inverted to compute a measure of distance. The Crohnbach's alpha with a value of 0.87 is again highly satisfactory to accept all of the indicators designed to measure the hypothetical construct 'organisational distance'.

The dimension **strategic distance** primarily addresses relational risks from inter-organisational co-operation and builds on the observed phenomenon – often referred to as co-opetition (Brandenburger & Nalebuff, 1996) – that co-operation and competition are simultaneously present in inter-organisational co-operation projects (section 4.4.4). However, the understanding of strategic distance goes beyond direct competitive relationships between the partners to consider the time dimension as well as the broader network of ties. Thus, it includes current or future, direct or indirect competitive relations between the partners. These constellations are embraced within the indicators forming the dimension strategic distance as presented in table 8.4.
The partner's perception of these relational risks was raised on a Likert-like scale with the end points 'strongly disagree' (1) and 'strongly agree' (5). Indicators 1, 2 and 4 were inverted to compute the distance between the partners. The resultant Cronbach's alpha has a value of 0.79. This value is rather high when taking a closer

Table 8.4: Indicators for the Construct Strategic Distance

Strategic distance	
1.	At the start of the co-operation project, we were already in a rivaling position.
2.	From the onset of the co-operative project, it was likely that the partner might be a future competitor.
3.	Our long-term strategic goals were compatible.
4.	The partner also engaged in co-operative links with other (potential) competitors.

look at the separate indicators: These indicators need not necessarily be in place simultaneously, but might add to relational risks. Considering these theoretical considerations, also a lower value of Cronbach's alpha would be justified.

Technological distance has been defined as people sharing the same knowledge bases, expertise and/or having accumulated comparable experiences due to similar historical paths (section 4.4.5). On the most obvious level, firms working in the same field of application (product market) will share some knowledge and expertise in their field. This can be accompanied and further backed by similarities in applied methods and techniques. Still, being active in the same product-market does not automatically imply having adopted the same methods and techniques. And vice versa, in a field such as biotechnology which can be rather defined as a generic technology flowing into many commercial applications, comparable technologies can be applied in different product market settings. However, also in cases where organisations have adopted divergent product market strategies as well as technological trajectories (specialised bodies of expertise), they may still share a common scientific knowledge-base (basic knowledge base). Hence, the most basic common denominator between the partners would then constitute shared disciplinary backgrounds of the employees; particularly the scientists and engineers. Furthermore, firms can also have accumulated knowledge in the partner's knowledge base through previous experience in the other's field of expertise. Thus, technological distance can be composed of various dimensions which contribute alone or together to a shared understanding and expertise. These are integrated into a single measure of technological distance (table 8.5).

The indicators are all raised according to the evaluation of the interviewee, using

Table 8.5: Indicators for the Construct Technological Distance

Technological distance
We shared experience, expertise, and thematic understanding due to an overlap in our...
1. ... product-market field
2. ... applied methods and techniques (specialised knowledge)
3. ... basic scientific disciplines of the team members (basic knowledge)
4. Understanding and interpretation was possible due to prior experience with the field of expertise of the partner.

five-point Likert-like scales with the end points ‘strongly disagree’ (1) and ‘strongly agree’ (5). The answers were again inverted to gain a measure of distance. The Cronbach’s alpha is 0.79.

The dimension **relational distance** builds on insights from Social Network Perspectives (section 4.4.6). It is known that network structures strongly shape patterns of interaction. They contribute to partner finding or formation processes but also convey ‘social capital’, comprising assets such as mutual trust and a feeling of reciprocity which ease the running of the co-operation. Relational proximity has been defined as ‘socially embedded relationships between agents at the micro-level’ (Boschma, 2005a, p. 66) which can be based on friendship, kinship and experience with the partner. Furthermore, some of the mechanisms identified also reach beyond the dyadic tie and include indirect ties in the network. Thus, the design of the construct needs to integrate different types of networks in which the relationships among the partners might be embedded. These ties can be of a formal or informal, direct as well as indirect nature (table 8.6).

The first three indicators represent direct prior relationships with the partner whereas the fourth one represents an indirect or ‘second order tie’. Here, a third party bridges the distance between the co-operating partners. Also in this constellation, social capital can be leveraged. In any case, presence and intensities of contact were raised in the interviews on an ordinal scale from one (‘strongly disagree’) to five (‘strongly dagree’). These were again inverted to calculate a measure of distance. In this case, the Cronbach’s alpha displays a rather low value of 0.32. This is inherent in the way, the construct was designed to capture various different types of relationships which

Table 8.6: Indicators for the Construct Relational Distance

Relational distance
The relationship with the partner was characterised by high affinity and trust from the onset due to
1. ... previous business relations among the partners.
2. ... personnel relations (employee movement, board interlocks).
3. ... prior informal relations.
4. ... third party referral.

are not mutually dependent but additive in their effect on social capital and hence relational proximity. Also the successive exclusion of indicators would not help to yield a more coherent construct. On the other hand, valuable information would be lost if any of the dimensions was to be omitted. For these theoretical reasons, all indicators were kept.

8.2.2 Operationalising Success

The operationalisation of the success of an inter-organisational co-operation project is an important step to be able to measure the effect of distance in any dimension on inter-organisational co-operation.

Generally, the choice of one or several success measures has to come up with three particularities of the unit of analysis: (1) the temporariness of a project; (2) its goal orientation and (3) the specific characteristics of R&D. First, the temporariness of projects leads to a rejection of any measure of longevity or survival of the inter-organisational venture, as is sometimes found in the literature on alliances and joint ventures (e.g., Hennart & Zeng, 2002; Park & Ungson, 1997; Harrigan, 1988). Second, co-operation projects generally pursue a specific goal. This goal orientation provides an immediate starting point for the evaluation of the success of a project. However, the integration of an external partner is also often motivated by a broader set of rationales which go beyond the realisation of the project. Moreover, inter-organisational co-operation is supposed to contribute many intangible assets, such as learning effects, which form an important outcome of inter-organisational co-operation, but which are often not directly envisaged or formulated beforehand (Hoang & Rothaermel, 2005). Hence, multiple dimensions need to be considered when evaluating the success of a co-operation project.[7] Moreover, the inclusion of multiple outcome dimensions allows probing different effects of distance. Third, R&D serves to develop new knowledge or generate innovation. Typical outputs of the invention process are publications as an early indicator as well as patents which signify the commercial value of an invention. Later achievements are prototypes or new or enhanced products, processes or services. However, the result of R&D does not always and immediately materialise in observable outcomes and often has no direct equivalent on the balance sheet.

Based on these considerations, a two-step approach has been developed which considers the achievement of the goals of the co-operation project, as well as its effects in respect to a set of further outcome categories (see Ermisch, 2007). While the first measure of goal achievement represents a global measure of success; the other categories consider distinct domains which together influence the achievement of the project's goals, but also extend the horizon to consider effects which go beyond the immediate goals of the project. They capture intended as well as non-intended, objective as well as subjective outcomes of the co-operation project (Nooteboom, 2004b; Zollo et al., 2002).

Again, most of the indicators represent perceptual measures, which have been evaluated by the interviewees. The indicators have been measured on 5-point Likert-like scales with the endpoints 'not achieved' (1) and 'exceeded expectations' (5) (e.g., Sammarra & Biggiero, 2008; Ermisch, 2007; Zollo et al., 2002).[8] Despite lacking objective verifiability, recent studies often rely on perceptual measures to evaluate co-operation success, and it has been observed that subjective, perceptual evaluations are highly correlated to objective ones (e.g., Sammarra & Biggiero, 2008; Ermisch, 2007; Nielsen, 2007; Mora-Valentin et al., 2004; Pothukuchi et al., 2002; Zollo et al., 2002; Saxton, 1997).

[7] There is no consensus within the literature on how to best measure the success of a co-operation project. Gray (2000) provides an overview of typical approaches to assess the success of inter-organisational co-operation, including: problem resolution or goal achievement; the generation of social capital; the creation of shared meaning; changes in the network structure and shifts in the distribution of power. These multiple outcome categories demonstrate the manifold facets of outcome of a co-operation that need to be considered.

[8] Zollo et al. (2002) state that many co-operation agreements 'evolve beyond partnering firms' initial expectations' (p. 706). Analogous, the endpoint 'exceeded expectations' was chosen to indicate projects which went beyond the expected level of outcome.

Step 1: Measurement of the degree of goal achievement

To construct an indicator of **goal achievement**, the interviewees were first asked to formulate up to three goals which were sought to be realised within the co-operation project. These goals were weighted by the interviewee according to their relative importance on a five-point scale ranging from 1 ('low importance') to 5 ('high importance'). In a second step, the interviewees were asked to indicate the level of goal achievement of each goal on a scale ranging from 1 ('not achieved') to 5 ('exceeded expectations'). This data on the importance of each goal and its achievement were combined to obtain a global measure of goal achievement for each project (formula 8.3).

$$GOA_i = \frac{\sum_{j=1}^{n} g_{ij} \cdot z_{ij} \cdot a_{ij}}{\sum_{j=1}^{n} g_{ij} \cdot a_{ij}} \tag{8.3}$$

GOA_i:	level of goal achievement of project i
g_{ij}:	importance of goal j for project i
z_{ij}:	evaluation of goal achievement of goal j for project i
a_{ij}:	activation index, $a_{ij} = 1$ if goal j exists, $a_{ij} = 0$ if goal j does not exist

The construct goal achievement measures whether the individually defined project goals had been achieved. However, the outcomes of the co-operation reach beyond the immediate achievement of the project's goals. To gain a more fine-grained picture, a set of further outcome dimensions has been designed which is outlined below.

Step 2: Operationalisation and measurement of further outcome variables

For the second step, five outcome categories have been defined that are each composed of a set of indicators: inventive; strategic/technological; efficiency; personal and relational outcomes. The indicators for each category have been raised on 5-point Likert-like scales with the end points 1 ('not achieved') and 5 ('exceeded expectations'). The calculation of the level of outcome achievement for each category followed Ermisch (2007) who proceeded according to formula 8.4.

$$Outcome_{ik} = \frac{\sum_{j=1}^{n} a_{ijk} \cdot z_{ijk}}{\sum_{j=1}^{n} a_{ijk}} \tag{8.4}$$

$Outcome_{ik}$:	level of outcome achievement of project i in regard to outcome category k
a_{ijk}:	activation index, $a_{ij} = 1$ if indicator j of category k can be evaluated, $a_{ij} = 0$ if indicator j cannot be evaluated by the interviewee
z_{ijk}:	evaluation of outcome achievement of indicator j within outcome category k for project i

First, the respondents were asked to evaluate the **inventive outcomes** of the co-operation project in regard to one or more of the following indicators (table 8.7):

Table 8.7: Indicators for the Construct Inventive Outcomes

Inventive outcomes
1. high quality publications
2. new IP
3. prototypes, new products, processes or services

The indicators can be assigned to different stages of the invention process with publications being associated with earlier stages; patents with later stages when applications become obvious, whereas prototypes or new or enhanced products, processes or services emerge in its final stages (Makri et al., 2010). Hence, it is expected that not every indicator applies to every co-operation project. This has to be considered when evaluating the co-operation project along the indicator system. However, in their entirety, they provide a comprehensive picture of the inventive outcomes generated within the co-operation project. The Cronbach's alpha of the construct has a value of 0.57. A lower value compared to the prior ones has been expected as the discussion has shown that not every indicator is representative for inventive advancement in every stage of the invention process.

In regard to **strategic outcomes**, the interviewees were asked to indicate whether the project has contributed to realise the strategic as well as technological aspirations of the firm and whether the partner satisfied the expectations in regard to the technical requirements (table 8.8).

Table 8.8: Indicators for the Construct Strategic Outcomes

Strategic/technological outcomes
1. achievement of strategic goals
2. achievement of R&D objectives
3. fulfillment of technical requirements

Again, the indicator set has been designed to describe different potential outcomes within the strategic and technological domain, for which a Cronbach's alpha of 0.64 is satisfactory to show consistent patterns in the answers.

Third, a construct to measure the efficiency (**operational outcomes**) of the co-operation project has been included. Theoretically, it has been suggested that distance might lead to additional costs or delays in the project time lines, which would be mirrored in this category. Moreover, although longevity is not a determinant of the success of a co-operation project, its stability over the envisaged time period is an important success criterion. The indicators designed to capture the operational outcomes are the following (table 8.9):

Table 8.9: Indicators for the Construct Operational Outcomes

Operational outcomes
1. compliance with co-operation budget
2. compliance with co-operation time lines
3. co-operation stability

The Cronbach's alpha has a value of 0.70 which proves the consistency of the construct.

The fourth category, **personal outcomes**, turns to the individuals who are involved in the project. It has been argued that some dimensions of distance might put personal strain on those involved, such as extensive traveling in the case of geographic distance or personal strain when technological distance exceeds cognitive abilities to exchange information. Hence, this dimension serves to reveal any of these suggested relationships concerning the individuals involved in the co-operation project. It is an indicator of the individual effort the co-operation has entailed. Moreover, individual learning effects beyond the focal project are included. Even, or particularly, in those cases where the co-operation project itself fails, important lessons can be learned for future co-operation projects. This body of experience constitutes itself a valuable asset for the firm. Table 8.10 presents the different indicators designed to measure the personal outcomes.

Table 8.10: Indicators for the Construct Personal Outcomes

Personal outcomes
1. personal satisfaction with partner performance
2. personal enjoyment of the co-operation project
3. positive learning effects from the co-operation

The Cronbach's alpha with a value of 0.83 ranks highest amongst the constructs and shows the high consistency in the answers regarding this construct.

The fifth and last construct, **relational outcomes**, integrates the relational and network level. It is accepted now that tie dissolution does not imply a failure of the co-operation, but can simply imply the finalisation of the project. Nonetheless, as a network of ties in itself is seen as an important organisational asset, a closer look at the development of the individual tie as well as the overall network position of the firm is included into the analysis. Although considering its transient nature, joint inter-organisational co-operation projects can lead to a trusted, long-term relationship that can be directly continued or latent existent, which implies that it can be re-mobilised in the case of future needs or opportunities. Furthermore, entry into a particular network can be an initial purpose of the co-operation project or a by-product of it. As social networks and the social capital they convey constitute important organisational resources, the outcome of the co-operation project in terms of achieved relationship quality or access to new partners are important outcome dimensions of a co-operation project. The final set of indicators is summarised in table 8.11.

Table 8.11: Indicators for the Construct Relational Outcomes

Relational outcomes
1. Development of a trust-based co-operation
2. Establishment of a long-term (active or latent) relationship
3. Cooperation opened access to other, new partners

These three indicators collect insights on the evolution of the individual tie (in terms of quality and duration) as well as on the evolution of the firm's network (emergence of new ties). The Cronbach's alpha has a value of 0.72, which is again a highly satisfactory value for the quality of the construct.

8.3 Empirical Findings

This section turns to the empirical findings. In section 8.3.1, a descriptive analysis of the firms in the sample and the case co-operation projects is presented. The main part constitutes section 8.3.2, in which the impact of different forms of distance between the partners and their interplay on the success of the co-operation project is evaluated empirically.

8.3.1 Descriptive Analysis

This subsection starts with a descriptive analysis of the firms that participated in the main interview phase, followed by a description of the case co-operation projects and a presentation of the summary statistics on the different dimensions of distance as well as the performance of the co-operation projects with regard to several outcome dimensions. The section closes with the presentation of some bivariate analysis models which provide first insights on the reach of the co-operation projects in regard to different dimensions of distance and their interrelationship.

Characteristics of the Firms

In the following, descriptive data of the unit of observation; i.e., the firms which participated in the main interview phase, is presented. The average **age** of the firms is nine years. The youngest firm was founded in 2007 and the oldest in 1984. The distribution of the firms with respect to their year of foundation is presented in figure 8.1. The largest share of the firms (34%) was founded between 1995 and 2000. 28% of the firms were founded between 2001 to 2005, 25% already before the year 1995 and another 13% after the year 2005.[9]

[9] This distribution mirrors the general development of firm foundation rates in Germany: its peak was reached between the mid and the end of the 1990s. It set off with the first governmental program to foster biotechnology R&D and commercialisation in Germany which was launched in 1995 (see Chapter 6) and decreased again with the downturn of the financial markets around the turn of the century.

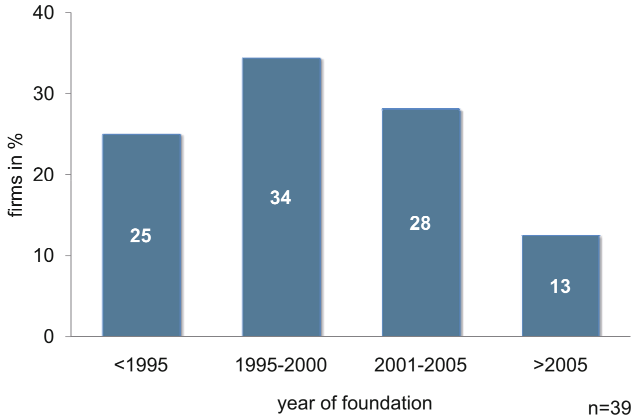

Figure 8.1: Year of Firm Foundation

Regarding the **size** of the firms, the majority of 44% employed 30 employees or less in the year 2008, followed by 19% who employed between 31 and 50 people (figure 8.2). 13% disposed over 51 to 100 employees, another 9% up to 200 and 16% employed more than 200 people. This high number of very small firms is characteristic for the German biotechnology industry (see Chapter 6).

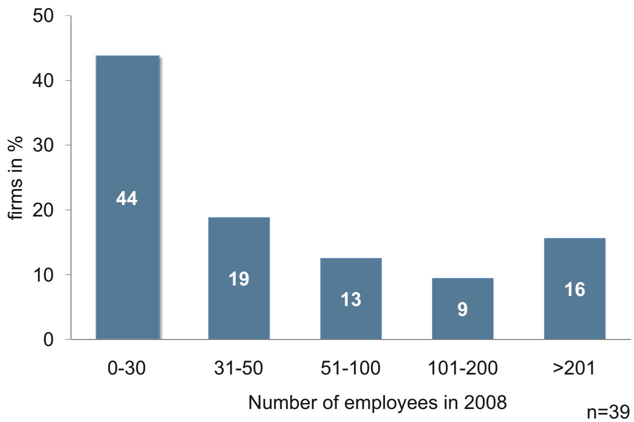

Figure 8.2: Size of the Firms (End of 2008)

With the rise of biotechnology commercialisation, a multiplicity of **business models** emerged. Three types of business models have been identified as central for the focal analysis: ‘product firms’, ‘service companies’ and ‘technology providers’ (Müller, 2003). Product firms focus on the development and commercialisation of a specific product or range of products (e.g. pharmaceutical compounds or diagnostic products), which are often based on a new proprietary technology. In some cases, the commercialisation is done in-house via an own marketing and sales unit, while in other cases, the products are out-licensed to external partners. Service companies offer mainly standardised services for other organisations, such as gene sequencing services or specific animal models for pre-clinical testing. Their competitive advantage can be based on a proprietary technology or else on a more basic technology which the firm masters at higher quality, larger scales and/or lower costs. The third category of firms, technology providers, comprises firms which base their business model on a proprietary technology in order to offer tailored R&D solutions for other firms. One specific of biotechnology business is that many firms pursue hybrid or dual business models which often consist of a service part, mainly based on a proprietary technology, with the parallel goal to become a fully-integrated product company. Accordingly, the firms could indicate that they pursued more than one type of business model. From figure 8.3 it can be seen that the majority of 41% of the firms classified its business model as a product firm. Service companies represent another 34%, while 25% of the firms classified themselves as technology providers.

Another characteristic of biotechnology business is a strong concentration on specific activities of the value chain and a high division of labour between distinct organisations. Fully integrated biotechnology firms which pursue all value steps internally are rather the exception than the rule (Rothaermel, 2001). Hence, the firms vary in regard to their **degree of vertical integration**. For most firms, R&D is the core business activity (figure 8.4). The majority of firms is active in the area of applied research (93%), followed by development activities (90%). Early development was less frequently named as it was often set equal to pre-clinical development activities which were often either not conducted in-house or which did not apply to the specific business field of the respective firm. Only 46% of the firms are active in this category. Also exploratory research is only pursued by 35% of the firms.[10] What is outstanding is the high number of firms which are active in upscaling and

[10] The majority of the interviewees expressed that exploratory research is mainly done in universities and other research institutes and that the firms start with applied research projects, often in-licensing promising ideas and techniques from research organisations.

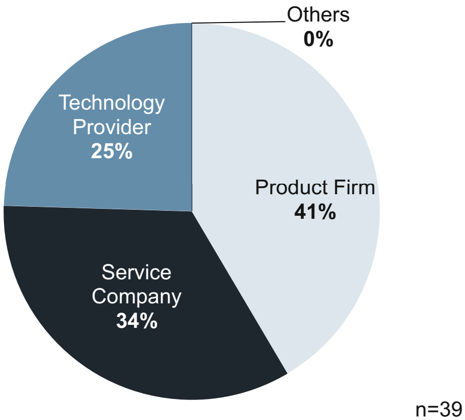

Figure 8.3: Type of Business Model

production (64%) as well as marketing and sales (69%). This finding can be traced back the pursuit of hybrid business models by many of the interviewed firms where early revenues are generated through the offering of services. Also here, multiple answers were possible.

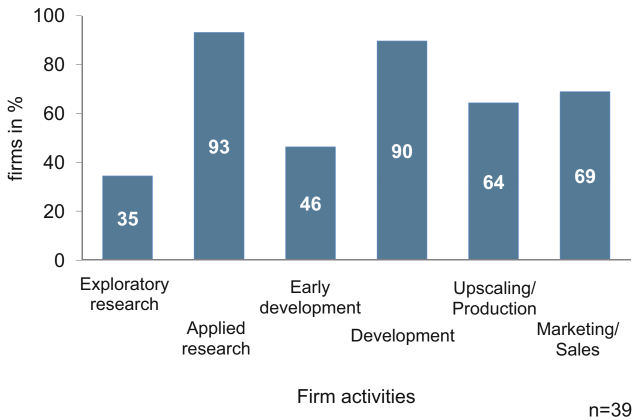

Figure 8.4: Degree of Vertical Integration

Turning to the R&D strategy of the firms, the interviewees were asked to indicate their **R&D intensity**, defined by their R&D expenses as a percentage of their annual income as an average of the years 2007 and 2008.[11] Corresponding to the high weight attached to R&D activities, it turns out that a great share of the firms' income is re-invested in R&D activities. From figure 8.5, two main groups stand out: First, there is a high share of firms (40%) with R&D intensities between 11 and 20%. Many of these firms are highly research intensive, but already generate revenues through the sales or out-licensing of products or offering of services. Second, there is a large group of firms (27%) which spends more than 75% of their annual income on R&D. These firms sometimes don't generate any revenues so far but are dependent on external funding. The rest of the firms is split more or less evenly among the other categories. Overall, this picture confirms the high significance of R&D for the firms.

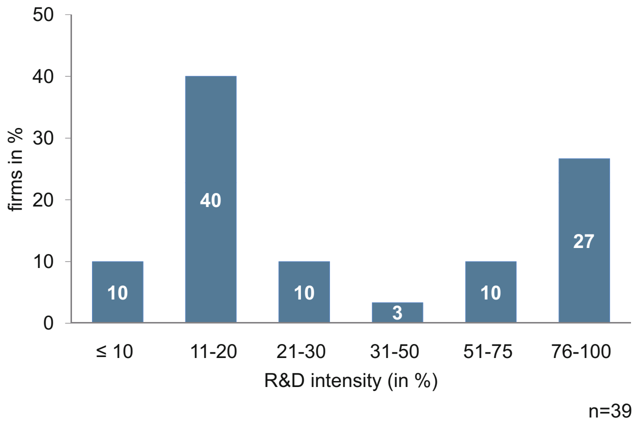

Figure 8.5: R&D Intensity (2007/2008)

This high share of R&D expenses on income is used to advance a certain **number of R&D projects** (figure 8.6). It strikes that the majority of the firms (73%)

[11] As many of the firms incur R&D expenses long before they begin to generate revenues from sales or out-licensing, all types of income (revenues as well as funds from venture capitalists or governmental programmes) were used as base value.

was active in more than five R&D projects during the five-year time period from 2003 to 2008, 40% of which indicated that they were engaged in more than ten projects. Another 23% had executed three projects during this period. Only 3% claimed to have been active in only two projects, while no firm indicated to have been engaged in only one project. Thus, the firms usually affect a high number of projects simultaneously or in close succession.

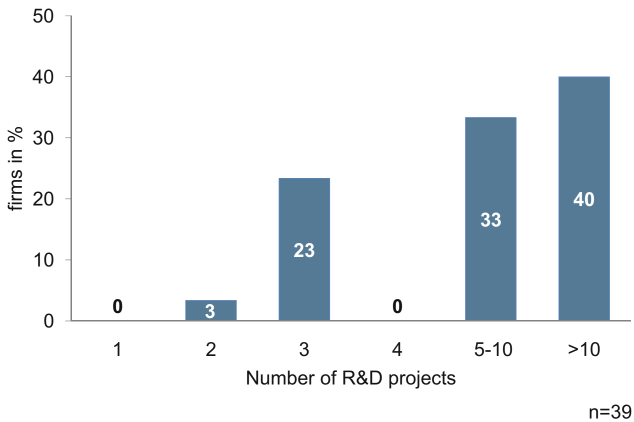

Figure 8.6: Number of R&D Projects (2003-2008)

With these R&D projects, the firms pursue different **goals** (figure 8.7). The projects aim foremost at the generation of new products (93%), followed by new knowledge or superior IP (60%), new or enhanced processes (53% each) and enhanced products (43%). Of lower importance are service innovations (27%), lower costs (23%) and organisational innovations (7%). Again, multiple goals could be named by the interviewees. This pattern is typical for the biotechnology industry which is driven primarily by the quest to commercialise new biotechnology knowledge in the form of new products or services. These are generally based on new methods and principles which are continuously advanced.

The high number of R&D projects is often not affected alone, but through interaction with external partners. Thus, the firms were further inquired about their

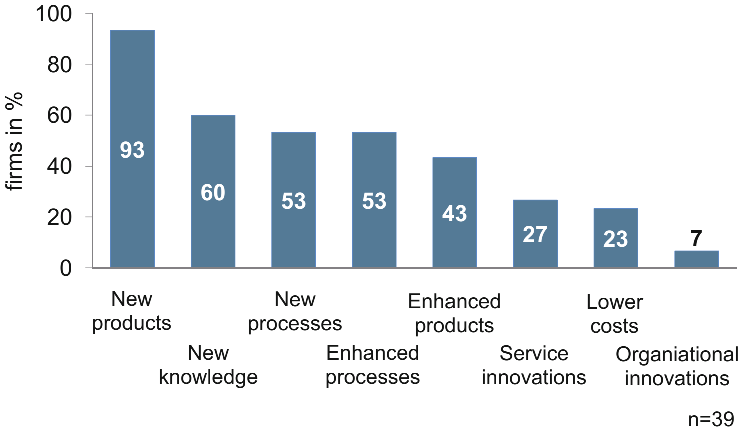

Figure 8.7: Goals of R&D Activities

general approaches toward inter-organisational co-operation in R&D.[12] Figure 8.7 presents an overview over the **number of partners** per firm in the field of R&D during the period from 2003 until 2008. During the five-year period, the majority of the firms (53%) was involved in five to ten inter-organisational co-operation projects in R&D. This is followed by 27% of the firms who even had more than ten partners in this time frame. A smaller number of 19% had between two and four partners, while no firm indicated that they had only one partner during this time window. This finding underscores the high significance that the firms attach to co-operation partners.[13]

[12] In the interview guideline, inter-organisational co-operation was defined as 'a (temporary) organisational arrangement (project) between two legally independent parties, where the parties explicitly agree to combine resources and capabilities in the area of R&D to achieve a pre-defined goal' (see Annex A).

[13] This high number of external partners is characteristic for the biotechnology industry. In Chapter 6, an average number of six co-operation partners has been cited (Gaisser et al., 2005).

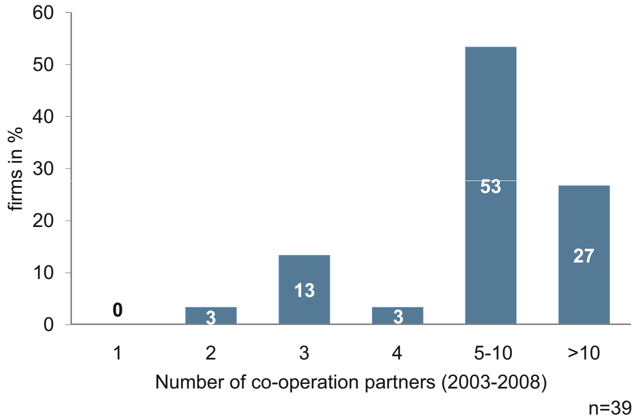

Figure 8.8: Number of R&D Partners (2003-2008)

In a subsequent step, the interviewees were requested to name their five **most important co-operation partners** and their respective locations (table 8.12).[14] It stands out that German and international partners are of equal importance for the firms. While German partners display a total number of 52 occurrences, 56 international partners are named. Most of these partners are found in the USA, followed by Switzerland, France, Japan and the United Kingdom.[15]

This step was followed by an analysis of the motives for engaging in inter-organisational co-operation in R&D in general. These are outlined later in this section and opposed to the motives for the case co-operation projects (figure 8.13).

[14] This summary also served as the basis to choose one case co-operation project for the in-depth analysis which followed.

[15] It needs to be underscored that this high share of international co-operation partners is not representative for the overall population of German biotechnology firms, as the sample was consciously selected based on the international experience of the firms.

Table 8.12: Locations of Most Important Partners for R&D

Country	#
National	52
International	56

No.	Country	#	No.	Country	#
1	United States (USA)	16	11	Sweden	2
2	Switzerland	9	12	Argentina	1
3	France	5	13	Australia	1
4	Japan	3	14	Austria	1
5	United Kingdom (UK)	3	15	Egypt	1
6	Canada	2	16	Finland	1
7	Denmark	2	17	Korea	1
8	Italy	2	18	Lithuania	1
9	Netherlands	2	19	Spain	1
10	Russia	2			

Characteristics of the Case Co-operation Projects

The final part of the descriptive analysis turns to the case co-operation projects as central unit of analysis. Regarding the **type of partner** which was selected for the inter-organisational case co-operation projects, figure 8.9 reveals that the majority of the partners are other firms (63%), followed by university groups (31%) as the second largest group. Together, these types of organisations represent 94% of the partners. Hospitals and other public research organisations (PROs) rarely occured as co-operation partners (3% each).

Moreover, 68% of the firms indicated that the partner's **position** vis-à-vis the focal firm **in the value chain** was unrelated (figure 8.10). In 16% of the case co-operation projects, the firms indicated that they had engaged in co-operation with a customer. Another 16% declared that they perceived the partner as a direct competitor. None of the partners was classified as a supplier to the focal firm.

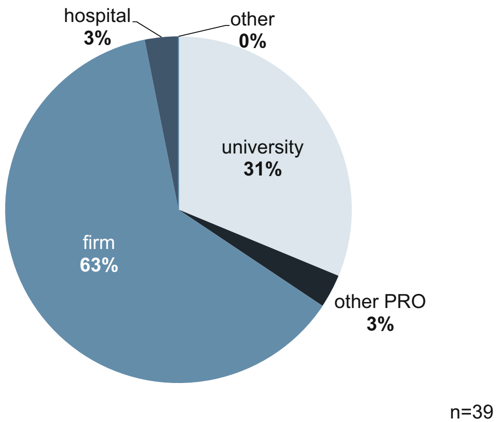

Figure 8.9: Type of Co-operation Partner

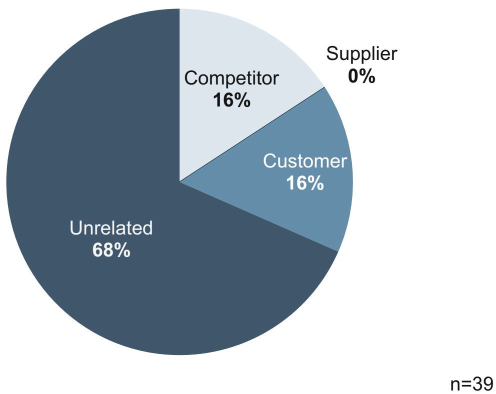

Figure 8.10: Positioning of the Partners along the Value Chain

In order to locate the co-operation projects in regard to their **invention stage**, the interviewees were asked to indicate whether the case co-operation project was characterised as basic research, applied research, pre-clinical development (early-stage development) or development (figure 8.11). It turns out that the projects are almost split evenly between joint research (49%, with 15% of the projects characterised as basic research and 34% classified as applied research) and development activities (51%, of which 11% are early or preclinical development projects and 40% late stage development projects). In this question, multiple responses were allowed.

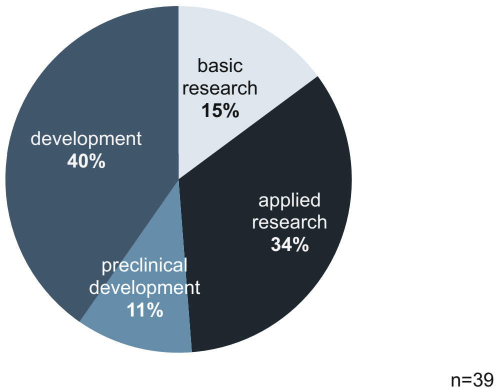

Figure 8.11: Invention Stage of the Case Co-operation Project

Further, the case co-operation projects varied with regard to their **duration**. While none of the projects was of a short duration ($\leq$ 12 months), the projects were split almost evenly between medium term projects ($> 12 \leq 36$ months, 47%) and projects which were defined as long term ($>$ 3 years, 53%).

Analogue to figure 8.7, the firms were requested to specify the **goals** of the respective case co-operation project (figure 8.12). In this question, multiple answers were possible. Again, the majority of 72% of the projects served to generate new products. This is followed in descending order by new processes (28%), enhanced products (25%), new knowledge or superior IP (16%) and enhanced processes (13%). Only occasionally the interviewees indicated that they also aimed to achieve organisational innovations (9%), lower costs (6%) or service innovations (3%).

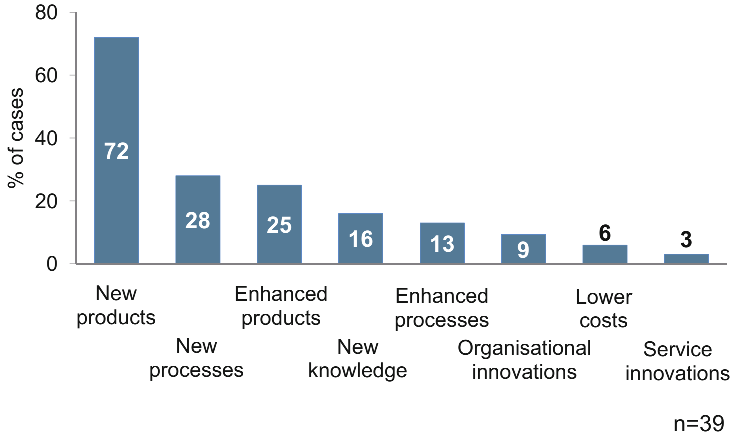

Figure 8.12: Goals of the Case Co-operation Project

These goals of the case co-operation projects differ from the **motives** to integrate an external partner. These motives can be manifold; and multiple motives can be pursued at the same time. Correspondingly, multiple answers were allowed. The motives were grouped into four categories: (1) Resources and capabilities; (2) Positioning; (3) Efficiency and (4) Policy/others. Each category is again composed of a set of different motives for inter-organisational co-operation in R&D (table 8.13).

The motives for engaging in inter-organisational co-operation were asked at two different stages of the interview: first, in part A of the interview guideline when the overall co-operation approach of the firms was explored. Second, in part B of the guideline, which focused on the specific case co-operation project. This procedure allows now to compare the general co-operation motives which are independent of partner nationality (dotted line in figure 8.13) with the specific motives for the international case co-operation projects (shaded area in figure 8.13). The scale ranged from 'low importance' (1) to 'high importance' (5). The figure presents the average values of the sample. Again, multiple motives could be named.

Table 8.13: Motives for Inter-organisational Co-operation in R&D

(1) Resources and Capabilities	(2) Positioning
Access complementarities	Create (de facto) standards, dominant designs
Realise synergies	Shape market structures
Learn	Enhance reputation, legitimacy
Secure future technological options	Access markets or networks
(3) Efficiency	**(4) Policy/Others**
Realise economies of scale/scope	Adapt fo market or regulatory requirements
Realise economies of time	Leverage supporting regulatory framework
Reduce costs, share risks	Access public funds of home/host government
Enhance flexibility	

With a mean value of 3.9 for the overall co-operation portfolio and 3.8 for the international case co-operation projects, the category 'resources and capabilities' ranks highest among the four categories. This implies that co-operation partners are foremost sought in order to leverage the partner's distinct resources and capabilities. Of the separate items within this category, access to complementary resources constitutes the dominant motive, followed by the realisation of synergies, learning and the aim to get an early stake in future technologies (secure future options). While the motive to learn ranks slightly higher in the international case co-operation projects, the realisation of synergies as well as the desire to secure future options in emerging technologies and methods are slightly more prevalent in the overall co-operation approach, including national as well as international partners.

The category 'positioning' ranks second in international co-operation projects; however third within the overall co-operation approach. However, the mean is 2.6 for both inter-organisational co-operation in general and the international case co-operation projects in particular. Also the evaluation of the single motives is close to congruent between the general and the international case co-operation motives. Foremost, the goal to build or strengthen the firm's reputation through the co-operation was named. This is followed by the motive to jointly create (de facto) standards or dominant designs. Moreover, international as well as national partners were also sought in order to access certain markets or the partner's networks;

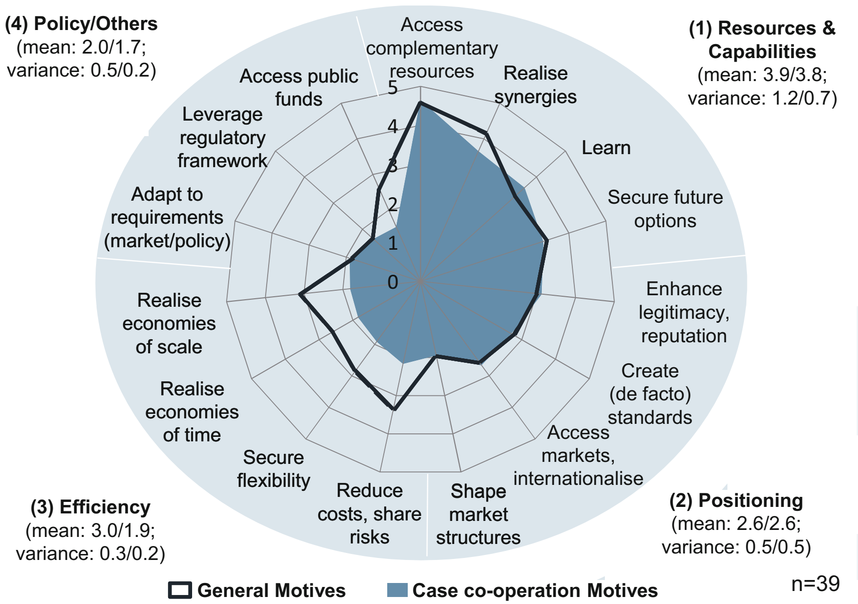

Figure 8.13: Motives for Engaging in Inter-organisational Co-operation Projects

although to a lesser extent. The goal to shape market structures through inter-organisational co-operation ranks lowest.

The third category, ‘efficiency’, displays the highest variation between the motives pursued in the firms’ overall co-operation approach and those pursued in the international case co-operation projects. It ranks second in regard to the overall co-operation portfolio with a mean of 3.0; however third in the international case co-operation projects with a comparably low mean value of 1.9. In descending order, the motive to reduce costs or share risks, secure flexibility, realise economies of time and economies of scale were named. Although it was mentioned that emerging countries offer low cost solutions, this motive was barely pursued by the interviewees.

The last category, ‘policy/others’, includes motives that relate to political framework conditions and incentives as a driver for inter-organisational co-operation in R&D. However, with a mean of 2.0 and 1.7, respectively, this category ranks lowest for both groups, the overall co-operation approach as well as the international case co-operation projects. All three motives – the need to adapt to external requirements (market/policy), to leverage a favourable regulatory framework and access to public funds – display low scores. The motive to access funds was of higher importance in the national context with the Federal Ministry for Education and Research sometimes named as the initiator for inter-organisational co-operation projects on a national level. This was more often the case than projects funded by the European Union which were only twice named as important international co-operation projects in R&D.

This analysis shows a broad variety in motives which are pursued within inter-organisational co-operation. All in all, it is outstanding that in international co-operation projects, quality issues strongly dominate market, cost and policy motives. Some interviewees explicitly expressed that international projects generally come at higher costs which must be outbalanced by the quality attributes of the particular partner.

Table 8.14 provides the summary statistics of the different dimensions of distance (as operationalised in section 8.2). It presents the mean values, standard deviations, minimum and maximum values, the scale range as well as the number of cases for each construct and indicator. Except for the construct geographic distance, the indicators of the different constructs were raised on five-point scales. For the summary table, an abbreviated form of the original hypothesis as presented in the interview guideline is used.[16] Furthermore, some of the statements needed to be inverted prior to their aggregation. These transformed values are indicated with a star. This results in the reading that low values of an indicator or construct in the table correspond to low levels of distance and high values correspond to high levels of distance across all indicators and constructs.

Turning to the dimension 'geographic distance', it has to be considered that most of the indicators were raised on metrical scales. Hence, they differ in their values and their aggregated construct value from the other constructs. Specifically, the aggregated value was constructed based on the z-standardised values of the single indicators.

[16] For the full hypothesis, see section 8.2 or the interview guideline in Annex A.

Table 8.14: Summary Statistics: Constructs and Measures of Distance

Variable	Mean	Std. Dev.	Median	Min	Max	Scale	N
Construct 'geographic distance'	0.0	0.9	-0.3	-1.4	2.0	-**	39
Metrical distance	3,321	3,275	1,196	190	9,468	km	39
Travel time	8.0	5.0	7.0	2.5	20.0	hours	39
Time difference	3.0	4.0	1.0	0.0	9	hours	39
Accessibility	3.1	1.0	3.0	1.0	5.0	1.0-5.0*	39
Construct 'institutional distance'	2.1	0.8	2.0	1.0	3.8	1.0-5.0	39
Similarity in regulatory framework	2.3	1.3	2.0	1.0	5.0	1.0-5.0	39
Similarity in norms, values	2.0	1.0	2.0	1.0	4.0	1.0-5.0	39
Similarity in culture, habits	2.0	0.9	2.0	1.0	4.0	1.0-5.0	39
Perception of language differences	1.7	0.8	1.0	1.0	3.0	1.0-5.0	39
Construct 'organisational distance'	3.0	1.1	3.0	1.0	5.0	1.0-5.0	39
Resemblance in basic goals and self-perception	3.1	1.3	3.0	1.0	5.0	1.0-5.0*	39
Resemblance in structures	3.3	1.5	3.0	1.0	5.0	1.0-5.0*	39
Resemblance in mode of operation	3.0	1.2	3.0	1.0	5.0	1.0-5.0*	39
Resemblance in organisational culture	2.8	1.2	3.0	1.0	5.0	1.0-5.0*	39
Construct 'strategic distance'	3.6	1.0	3.8	1.3	5.0	1.0-5.0	39
Current rivals	4.3	1.2	5.0	1.0	5.0	1.0-5.0*	39
Potential future rivals	3.8	1.4	4.0	1.0	5.0	1.0-5.0*	39
Goal compatibility (long-term)	3.3	1.4	4.0	1.0	5.0	1.0-5.0	39
Indirect spill-over risk	3.1	1.1	3.0	1.0	5.0	1.0-5.0*	39
Construct 'technological distance'	2.5	1.0	2.3	1.0	4.7	1.0-5.0	39
Overlap in product-markets	3.2	1.5	3.0	1.0	5.0	1.0-5.0*	39
Overlap in methods and techniques	3.0	1.2	3.0	1.0	5.0	1.0-5.0*	39
Overlap in basic scientific disciplines	2.3	1.1	2.0	1.0	5.0	1.0-5.0*	39
Prior experience	2.3	1.1	2.0	1.0	4.0	1.0-5.0*	39
Construct 'relational distance'	4.3	0.6	4.5	2.5	5.0	1.0-5.0	39
Prior business ties	4.4	1.0	5.0	2.0	5.0	1.0-5.0*	39
Prior personnel relations	4.6	0.8	5.0	2.0	5.0	1.0-5.0*	39
Prior informal relations	4.0	0.9	4.0	2.0	5.0	1.0-5.0*	39
3^{rd} party referral	4.1	1.0	4.0	2.0	5.0	1.0-5.0*	39

1 := low levels of distance
5 := high levels of distance

* = scale reversed
** = z-standardised

The average metrical distance between the co-operation partners was 3,321 kilometers. However, the data is characterised by a high dispersion in regard to the metrical distance separating the partners, which is captured by the high standard deviation. The smallest distance between the partners was 190 kilometers, whereas the largest was 9,468 kilometers. The travel time to the partner varied between 2.5 and 20 hours, with an average travel time of 8 hours, measured from site to site. Likewise, the time difference between the partners was mostly low with a mean of 3 hours and a range from zero to 9 hours. The accessibility of the partner was on average perceived as medium with a mean of 3.1 and a median of 3.

In figure 8.14, the geographic distribution of the case co-operation projects is graphically depicted. It becomes evident that the projects vary considerably in regard to the geographic distance they incur. However, the geographic distribution of the partners is not even across the globe, but highly concentrated within a few regions and places worldwide. Of the case co-operation partners, 60% were located in Europe, 31% in the USA or Canada (particularly in global hotspots such as Boston, New York and San Diego) and only 6% in Asia and 3% in other countries (in this case Egypt). This distribution displays a high concentration of the partners within European countries, particularly in Switzerland, followed by the UK, the Netherlands, Sweden, Austria, France and Italy. One co-operation partner was located in Spain, one in Denmark and one in Poland. Furthermore, most US or Canadian partners were located at the east coast of North America.[17] This distribution is also reflected in the values of the institutional dimension of distance (table 8.14).

The construct 'institutional distance' averages 2.1. With a scale range from one to five, this construct displays the lowest value of all dimensions. The interviewees didn't use the whole scale range with the maximum value constituting 3.8. Moreover, differences in the institutional set-ups of the countries were generally perceived as higher (mean: 2.3, median: 2), whereas language differences were perceived as particularly low (mean: 1.7, median: 1). This distribution shows that, apart from a few exceptions, the level of institutional distance within the case co-operation projects was mostly perceived as low. It seems that the firms are reluctant to incur high degrees of institutional distance in their partner networks.[18]

[17] This geographic distribution mirrors the overall country distribution of the five most important co-operation partners of the firms which has been summerised in table 8.12.

[18] A couple of firms explained that they currently consider or recently launched co-operation projects with East-Asian partners. All interviewees agreed that this topic has or will become

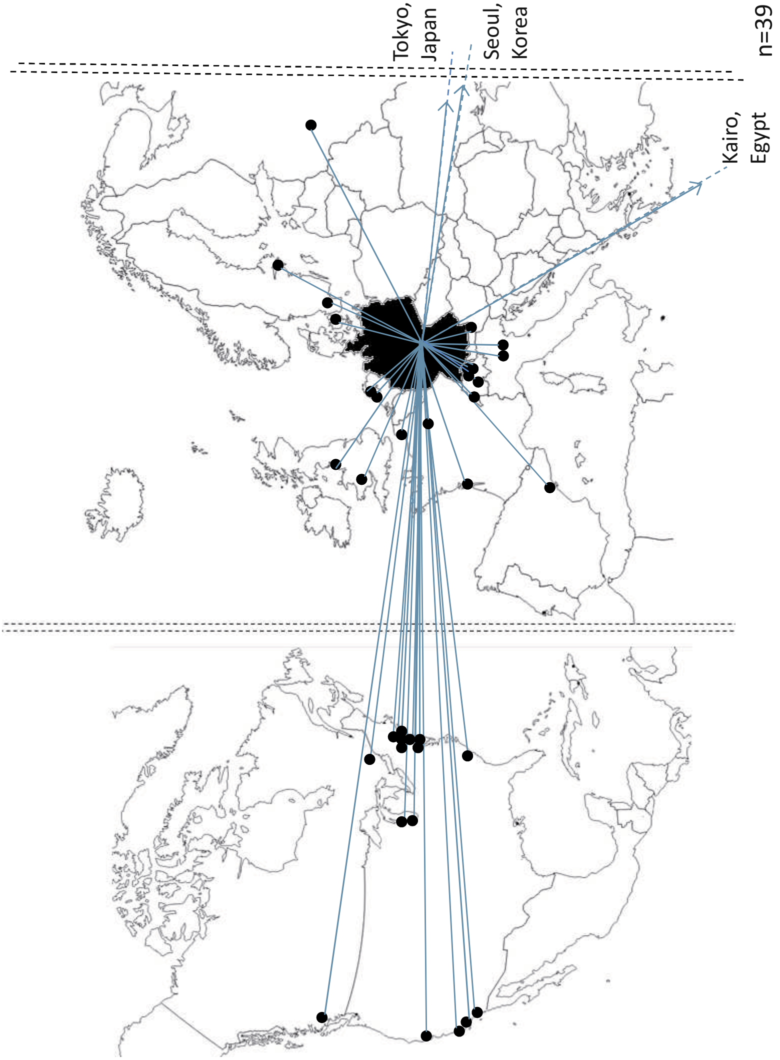

Figure 8.14: Geographic Distribution of Co-operation Partners

The construct ‘organisational distance’ displays a comparatively higher mean value of 3.0. Within this dimension, the interviewees used the whole scale range from one to five. Taking a detailed look at the single indicators of the construct, one observes that the partners display on average higher differences in structural terms (mean: 3.3, median: 3), while they are more likely to be comparable in regard to their organisational culture (mean: 2.8, median: 3). However, also within this indicator the whole scale range was used, which suggests high differences in the individual cases. Thus, the argument of a preferential attachment to homophilous or similar partners needs to be relativised: the firms tend to select partners based on their resources and competences; yet, they are frequently looking for partners which are characterised by similar cultures and values.

The construct ‘strategic distance’ displays the second highest mean value of 3.6. Together with a minimum value of 1.3, these comparatively high values indicate that the focal firms rarely perceived their partners as direct or indirect, current or future competitors. The different indicators of this construct reveal that in most of the cases, the focal firms didn’t perceive their partners as current (mean: 4.3, median: 5) or future (mean: 3.8, median: 4) competitors. The lowest value is revealed for the indicator ‘indirect spill-over risk’ (mean: 3.1, median: 3), indicating that it was rather perceived as likely that the partner also engaged in co-operation with other partners who might be (current or future) competitors of the focal firm or vice versa.

Following institutional distance, the construct ‘technological distance’ displays the second lowest evaluations. Its mean value is 2.5 and its maximum value is 4.7; implying that the partners move within a rather narrow technological scope, although variation between the cases exists. Furthermore, the single indicators reveal one more interesting aspect: the values of the two indicators which capture the specialised knowledge of the partner – ‘overlap in product-market knowledge’ (mean: 3.2, median: 3) and ‘overlap in methods and techniques’ (mean: 3.0, median: 3) – display higher values of distance than the two variables which capture a more fundamental or basic understanding shared between the partners – ‘overlap in disciplines’ (mean: 2.3, median: 2) and ‘prior experience’ in the field of the partner (mean: 2.3, median: 2). The conclusion can be drawn that the majority of firms looked for distinct specialised knowledge and capabilities of their partner, but didn’t reach out far beyond the confines of their own basic area of knowledge and expertise.

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an issue for their firm. However, some firms hesitated, perceiving inter-organisational co-operation with partners from these emerging countries as more challenging or risky.

Compared to the other constructs, the construct 'relational distance' displays the highest mean value of 4.3. In the interviews, it turned out that a large share of the projects was initiated from scratch. The relatively high mean value of the indicator 'prior business ties' (mean: 4.4, median: 5) suggests that the case co-operation projects only on rare occasions tended to build on or re-moblise existing R&D partners. Also personnel links, which also comprised links in the scientific advisory boards were largely not present prior to the focal case co-operation project (mean: 4.6, median: 5). If ties between the partners existed before, these were primarily of an informal nature (mean: 4.0, median: 4) or they were based on the recommendation of a third party (mean: 4.1, median: 4). In some cases, partnerships were recommended or dictated from the management level, based on their social networks. All in all, this result is interesting as it relatives the role of social networks for partnership formation. A large share of the co-operation projects in the sample followed a primary economic rationale, which was based on the search for specific complementary resources or new scientific or technological insights. The means to identify potential partners are broad: the world wide web, publications, patents and industry fairs or conferences are all platforms to identify new partners. The global biotechnology industry is quite transparent.

A correlation analysis shows that the different dimensions of distance are largely uncorrelated (table 8.15).[19] There is only one statistically significant correlation between the organisational and the strategic dimension ($p<.10$). This result suggests that organisations which are perceived as organisationally distant are also often evaluated as strategically distant and vice versa. Typical examples would be firm–university co-operation projects or co-operation projects between dedicated biotechnology SMEs and large firms.[20]

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[19] Tables 8.15 and 8.16 are extracted from the full correlation matrix which is included in table C.1 in Appendix C.

[20] In regard to the other dimensions, no statistically significant correlations exist. However, four more findings are interesting. First, though not statistically significant, the relatively high correlation value between geographic and institutional distance indicates that geographic distance is at times accompanied by increasing institutional distance. Second, the negative correlation between geographic and technological distance suggests that partners who are located far away tend to be closer in their knowledge basis and expertise. In these cases, a global tie in a very narrow epistemic field is spanned across the globe. Third, there is also a negative sign between institutional and relational distance. This result suggests that ties with partners from institutionally distant countries are sometimes based on previous

Table 8.15: Correlation Analysis: Interdependencies in the Forms of Distance

	(1)	(2)	(3)	(4)	(5)	(6)
(1) Geographic distance	1.00					
(2) Institutional distance	0.25	1.00				
(3) Organisational distance	0.01	0.06	1.00			
(4) Strategic distance	-0.05	-0.13	0.28†	1.00		
(5) Technological distance	-0.25	0.18	0.22	-0.11	1.00	
(6) Relational distance	-0.11	-0.20	0.02	0.01	-0.03	1.00

† p<.10

At this point, also the role of the suggested intermediary variables – invention stage and learning rationale – as possible determinants for the reach of the co-operation projects in respect to different dimensions of distance is explored. For each intermediary variable, a bivariate variable is created, taking the value one in case of a research project and in the presence of a strong learning rationale, and zero otherwise.[21] The results display no significant relationships between the invention stage, respectively the learning rationale, and the reach of the co-operation project in any of the dimensions. One notable exception is a high correlation coefficient (p<.01) between the invention stage and technological distance. This finding suggests that in research projects the firms tend to reach out farther to distant sources of knowledge and technologies which contribute novelty to the firm and yield novel combinations.

acquaintance or recommendation. Lastly, the correlation between organisational and technological distance displays a positive sign, implying that partners which are organisationally distant are eventually sought for new or distant knowledge. However, these correlations are not statistically significant; i.e., they are not valid for all the cases in the sample population.

[21] For the analysis, the sample of co-operation projects has been split into two sub-groups, distinguishing between research and development as well as between different learning rationales. The descriptive analysis has revealed that the sample is split almost evenly between research (49%) and development projects (51%). A strong learning intent has been defined as a score of four or five in the motives for the co-operation project. Ohterwise, a weak learning intent is assumed. Similarly, the sub-groups as defined by their learning rationale are of equal size with 48% of the cases indicating a strong learning rationale compared to 52% which scored the motivation to learn as three or below.

Table 8.16: Correlation Analysis: The Impact of Intermediating Variables

	Geographic distance	Institutional distance	Organisational distance	Strategic distance	Technological distance	Relational distance
Invention stage	-0.23	-0.04	-0.04	0.05	0.34**	-0.12
Learning rationale	-0.01	-0.21	-0.02	0.00	-0.06	0.15

** p < .01

This finding from the correlation analysis is also corroborated by other statistical tests; a Kruskal-Wallis equality-of-populations rank test to examine differences in the distribution between the sub-populations, and a median test to reveal potential differences in the means of the sub-populations.

Table 8.17 presents the results in regard to the invention stage. The tests corroborate the finding from the correlation analysis that the invention stage is not decisive in the reach of the co-operation project in regard to various dimensions of distance; except for a significant relationship between the invention stage and technological distance, which is supported by both tests ($p<.05$). Moreover, the Kruskal-Wallis test suggests differences in the sub-populations in regard to the relational dimension of distance ($p<.10$). Research projects are more likely to be conducted with relationally closer partners compared to development projects. It can be suggested that the choice of a development partner is often based on a more strategic and conscious search process for a suitable partner. By contrast, research partnerships are often initiated by a novel idea or approach, the identification of which is often reliant on personal acquaintance and word-of-mouth.

In table 8.18, the respective test results in regard to the co-operation rationale are summarised. As suggested by the results of the correlation analysis, the sub-populations display no differences in the reach of project in regard to most of the dimensions of distance. However, one more interesting relationship is revealed by the tests: Both tests suggest that projects which serve to absorb the partners knowledge are more sensitive to institutional distance; i.e., the firms seem to avoid high levels of institutional distance ($p<.05$). Conversely, projects which are characterised by a division of knowledge where the partners aim to access the resources of the partner, are more willing to engage in co-operation with institutionally distant part-

Table 8.17: Sub-group Comparison: Differences According to the Invention Stage

	Geographic distance	Institutional distance	Organisational distance	Strategic distance	Technological distance	Relational distance
Kruskal-Wallis test						
χ^2	0.94	0.12	0.11	0.05	4.37	3.22
p	0.33	0.73	0.74	0.83	0.04	0.073
Median test						
χ^2	2.42	2.32	3.23	1.15	6.31	0.45
p	0.30	0.31	0.20	0.56	0.04	0.80

Table 8.18: Sub-group Comparison: Differences According to the Learning Rationale

	Geographic distance	Institutional distance	Organisational distance	Strategic distance	Technological distance	Relational distance
Kruskal-Wallis test						
χ^2	0.121	3.848	0.030	0.182	0.993	1.484
p	0.728	0.049	0.862	0.669	0.319	0.223
Median test						
χ^2	0.444	42.078	1.003	0.112	0.112	2.215
p	0.505	0.040	0.317	0.738	0.738	0.137

ners. There are two possible explanations for this finding. First, in reference to learning theory and the ability to uptake knowledge from external source, it can be suggested that firms face difficulties in absorbing knowledge from institutionally distant partners. Second, a more industry specific reason might be found in the current geographic distribution of biotechnology business and excellence. The global lead is still found in the US, where a high number of firms and research institutes constantly produces front-edge scientific and technological output. Newly emerging biotechnology nations are often still in a catch-up process, particularly in regard to research excellence. Partners in these countries are rather sought to yield cost advantages in the delivery of standardised tasks and solutions; which might rather be sought in co-operative development than research.

Finally, table 8.19 provides the summary statistics for the **outcome variables**.

Table 8.19: Summary Statistics: Levels of Success in Different Categories

Variable	Mean	Std. Dev.	Me-dian	Min	Max	Scale	N
Construct 'Goal achievement'	3.7	0.9	3.9	1.0	5.0	1.0-5.0	39
1^{st} goal	4.0	0.9	4.0	1.0	5.0	1.0-5.0	39
2^{nd} goal	3.3	1.1	3.0	1.0	5.0	1.0-5.0	38
3^{rd} goal	3.8	0.6	4.0	3.0	5.0	1.0-5.0	35
Construct 'Inventive outcomes'	3.4	1.1	3.4	1.0	5.0	1.0-5.0	37
Publication output	3.0	1.5	3.0	1.0	4.0	1.0-5.0	37
Patent output	3.1	1.3	3.0	1.0	5.0	1.0-5.0	36
New/enhanced products, processes, or services	3.6	1.4	4.0	1.0	5.0	1.0-5.0	37
Construct 'Strategic outcomes'	3.9	0.8	4.0	1.7	5.0	1.0-5.0	38
Achievement of strategic goals	3.7	1.0	4.0	1.0	5.0	1.0-5.0	38
Achievement of R&D goals	3.9	1.1	4.0	1.0	5.0	1.0-5.0	38
Fulfillment of technical requirements	4.0	0.9	4.0	2.0	5.0	1.0-5.0	38
Construct 'Operational outcomes'	3.6	0.8	3.7	1.0	5.0	1.0-5.0	37
Compliance with budget	3.7	1.0	4.0	1.0	5.0	1.0-5.0	36
Compliance with timelines	3.1	0.9	3.0	1.0	5.0	1.0-5.0	37
Cooperation stability	4.0	1.0	4.0	1.0	5.0	1.0-5.0	37
Construct 'Personal outcomes'	3.9	0.9	4.0	1.0	5.0	1.0-5.0	39
Satisfaction with partner performance	3.8	1.1	4.0	1.0	5.0	1.0-5.0	39
Personal enjoyment of co-operation	3.9	0.9	4.0	1.0	5.0	1.0-5.0	39
Positive learning effects	4.0	1.0	4.0	1.0	5.0	1.0-5.0	39
Construct 'Relational outcomes'	3.3	0.9	3.3	1.0	4.7	1.0-5.0	39
Development of trust	3.9	1.1	4.0	1.0	5.0	1.0-5.0	39
Establishment of long-term relationship	3.7	1.2	4.0	1.0	5.0	1.0-5.0	39
Access to new partners	2.4	1.2	2.5	1.0	5.0	1.0-5.0	39

1 := low levels of success
5 := high levels of success

The different outcome dimensions have been raised on five-point scales with the end-points 'not achieved' (1) and 'exceeded expectations' (5) (see section 8.2). First, the construct 'goal achievement' as global measure of the project's success has taken on all scale ranges from one to five, with a mean value of 3.7 but considerable variance. While all interviewees could evaluate the degree of achievement of the first goal (n=39), the number of responses for the second (n=38) and third (n=35) goals were lower. This has two reasons: First, some respondents formulated less than three goals; second, the second or third goals were often of a more long-term nature and could not be properly evaluated by some at the time of the interview.

Second, a set of further outcome categories had been operationalised to obtain a more fine-grained picture on the benefits as well as difficulties of inter-organisational co-operation projects. The category 'inventive outcomes' captures the outcomes of the co-operation projects as materialised within publications, patents or new products, processes or services. Overall, the category displays a relatively low mean value of 3.4 compared to the other outcome categories. However, the whole scale range from one to five was used, displaying a rather high variance in the evaluations. What must be acknowledged is that some interviewees noted that it was too early to evaluate the co-operation project with respect to publication and patent outcomes, which were either in planning or in preparation at the time of the interview. Thus, the interviewees could not yet evaluate the final results which resulted in a lower number of respondents for these indicators. Moreover, the case projects served primarily to generate new or enhanced products or processes, not patents or publications in the first place. Correspondingly, the highest values are reported with respect to new products, processes or services (mean: 3.6, median: 4), while publications and patents received lower evaluations with mean values of 3.0 and 3.1, respectively, and median values of 3 for both.

The category 'strategic outcomes' displays the highest mean value of 3.9. While the lower limit is 1.7, there is still high variance in the data. Specifically, the indicators which are related to R&D and the partner's capabilities were mostly rated as high. This applies to the satisfaction with the partner's 'fulfillment of technical requirements' (mean: 4.0, median: 4), as well as the 'achievement of the R&D goals' (mean: 3.9, median: 4). The achievement of further strategic goals is slightly lower with a mean of 3.7 and a median of 4.

The construct 'operational outcomes' has a mean value of 3.6; and again the whole scale range was used. Thus, the partnerships remained mostly stable over the intended course of the project (mean: 4.0, median: 4). Moreover, the allocated budget was mostly not exceeded (mean: 3.7, median: 4). Only the evaluation of the project's adherence to time lines was lower (mean: 3.1, median: 3). Some interviewees admitted that they experienced delays in the project's schedule or that they had expected the results to materialise earlier.

Along with the strategic outcome dimension, the 'personal outcomes' category displays the highest mean value of 3.9; again with considerable variance in the evaluations which took all values from one to five. Above all, a large share of the interviewees reported high 'positive learning effects' from the co-operation (mean: 4.0, median 4), followed by 'personal enjoyment of the co-operation' (mean: 3.9, median: 4) and the interviewees' degree of 'satisfaction with the partners' performance' (mean: 3.8, median: 4).

The last category turns to the quality of the relationship as well as the effect of the co-operation project on the overall network. This category is rated lowest amongst the outcome categories; although again the whole scale range was used by the interviewees. However, the mean value for 'development of a trust-based relationship' is the highest (mean: 3.8, median: 4), suggesting that the partners managed to establish high levels of trust in each other within the project. Thus, the low result is primarily due to the fact that most co-operation projects did not turn out as immediate door openers to other co-operation projects (mean: 2.4, median: 2.5). Other interviewees indicated that it was too early to profit from increased reputation or network effects. Moreover, a number of interviewees didn't perceive access to other partners as a prime quest within the focal co-operation project. Similarly, the 'establishment of a long-term relationship' (mean: 3.7, median: 4) was often not core to the co-operation project which was foremost of a timely restricted nature in order to realise a specific goal. However, except for two cases where the project discontinued before the intended deadline, the partners would eventually be mobilised again in the future, provided a demand for their expertise eventuated.

All in all, considerable variance in the data exists, indicating differences in the perceived success or contribution of the co-operation project.

8.3.2 Multivariate and Qualitative Analysis

In this section, the results of the empirical analysis regarding the impact and interplay of the different dimensions of distance are presented. To calculate the effects of distance individually and in their combination, a multivariate model is applied which is introduced below. For the interpretation of the statistical results, the qualitative information gained through the personal interviews are used. Thus, the empirical findings from the multivariate analysis are combined as well as corroborated with statements from interviewees expressing their opinions, views and experiences. Opposing views, majority as well as minority views are included to explain the multivariate results. Further, the qualitative analysis revealed that there is a set of central moderating variables, which influenced the actual or perceived effect in each dimension. These moderating variables are discussed within the presentation of the qualitative insights.

Technical Notes on the Model

To analyse the impact and interplay of distance in different dimensions on goal achievement and further outcome categories, several regression models were run.[22] The selection of an appropriate model was primarily determined by the characteristics of the dependent variable. Through the weighting and aggregation of the dependent variable (see section 8.2), a continuous variable has been created, which is however limited to values between one (lower limit) and five (upper limit). Thus, a Tobit model has been chosen, which is a type of regression analysis which was introduced in order to handle dependent variables which are limited (Amemiya, 1984; Tobin, 1958).[23] A limited dependent variable model implies that the values of the

[22] The selection of regression analyses was made due to their capacity to identify relationships between explanatory and dependent variables, to simultaneously integrate various variables, which is a particular advantage compared to bi-variate correlation analysis, and the possibility to include non-linear and interaction effects. Also partial least square (PLS) models were considered as an alternative, particularly due to the relatively small sample size (Panten & Boßow-Thies, 2007; Tenenhaus et al., 2005). However, they were rejected as the inclusion of non-linear as well as interaction effects proved problematic. However, this is an important assumption in this thesis.

[23] For more information on regression methods in general and the Tobit model in particular, see also econometric textbooks, such as Cameron and Trivedi (2009), Wooldridge (2000) or Pindyck and Rubinfeld (1997).

dependent variable are restricted to a certain range of values; i.e., they have an upper, lower or double-sided limit. In this case, information on the dependent variable is incomplete, while the corresponding information for the independent variables is given (Pindyck & Rubinfeld, 1997). Applying more classical multiple regression methods, such as ordinary least squares (OLS), when the dependent variable is limited can lead to biased estimators.

Unlike the more prevalent OLS regression, the standard method to calculate a Tobit regression is the maximum likelihood method (see, e.g. Cameron & Trivedi, 2009; Wooldridge, 2000).

The general Tobit model is written in the form of a latent dependent variable model, where y_i^* is a linear combination of x_i and an error term ϵ_i (equation 8.5).

$$y_i^* = x_i'\beta + \epsilon_i, with \epsilon_i \sim N(0, \sigma^2) \tag{8.5}$$

The error term ϵ_i is normally distributed with a mean of zero and variance σ^2. The expected value of the latent variable is $E(y_i^*) = x_i'\beta$.

In the present case, the dependent variable is double-sided limited, which implies that the values below the lower as well as above the upper limit are unobserved. With a as the lower limit and b as the upper limit, the observed variable y is related to the latent variable y_i^* in the following way (equation 8.6, adapted from Cameron & Trivedi):

$$y_i = \begin{cases} y_i^* & if \quad a < y_i^* < b \\ a & if \quad y_i^* \leq a \\ b & if \quad y_i^* \geq b \end{cases} \tag{8.6}$$

The probability of an observation being left-censored is $Pr(y_i^* \leq a) = Pr(x_i'\beta + \epsilon \leq a) = \Phi\{(a - x_i'\beta)/\sigma\}$, where $\Phi(\cdot)$ is the standard normal cumulative distribution function (and vice versa for the upper limit).

From these considerations, a function of the conditional expectation of y as dependent on $x_i'\beta$ and an additional term is derived (equation 8.7). This additional term corrects for the fact that values of y beyond the limit values a and b are not observed, but only the rim solutions.

$$E(y_i|x, a \leq y \leq b) = x_i'\beta + \sigma \cdot \frac{\phi\left(\frac{a - x_i'\beta}{\sigma}\right) - \phi\left(\frac{b - x_i'\beta}{\sigma}\right)}{\Phi\left(\frac{a - x_i'\beta}{\sigma}\right) - \Phi\left(\frac{b - x_i'\beta}{\sigma}\right)} \tag{8.7}$$

In equation 8.7, a and b represent again the lower and upper limits, and $\phi(\cdot)$ stands for the standard normal density function. From this equation it can be seen that in a censored model, $E(y_i|x) \neq x_i'\beta$. In this case, the expected value of the dependent variable as calculated according to classical OLS would yield biased coefficients (Cameron & Trivedi, 2009).

Specification of the Model

The main building blocks for the regression model are the constructs for the different dimensions of distance and success, or outcomes, of the co-operation projects. However, the descriptive analysis has revealed considerable heterogeneity in the sample in regard to the firms as well as the case co-operation projects. Hence, a set of control variables is integrated into the regression models. Together, the outcome of a co-operation project is perceived as a function of the distance in different dimensions and the set of control variables (equation 8.8).

$$Outcome = f(distance; controls) \tag{8.8}$$

The control variables are summarised in table 8.20. They are subdivided into two domains: firm characteristics and co-operation characteristics.

In respect to deviating firm characteristics, the two variables firm **size**, approximated by the number of employees at the end of 2008, and **age** measured in terms of the number of years since foundation up to the year 2008, have been included in the models. First, it can be assumed that large firms can allocate more resources to the co-operation project. Besides, they can be assumed to be more diversified in regard to their internal knowledge base. Second, they might be more robust and prepared against eventual failures and less risk averse. Older firms might be more experienced in projects as well as in inter-organisational co-operation. Thus, size and

Table 8.20: Summary of Control Variables

Domain	Variable	Description	Scale
Firm characteristics	*Structural variables*		
	* Firm size	Number of employees (end of 2008)	metrical
	* Firm age	Number of years since foundation	metrical
	R&D strategy		
	* R&D intensity	Income spent on R&D activities (2008)	metrical
	* R&D breadth	Number of R&D projects (2003-2008)	metrical
	Co-operation strategy		
	* Network Centrality	Number of R&D partners (2003-2008)	metrical
Co-operation characteristics	Duration	Duration of the co-operation project; long-term = 1, medium-term = 0	binary
	Invention stage	Location of the project in the invention stage; research = 1, development = 0	binary
	Co-operation rationale	Dominant motivation for co-operation, learning = evaluation on Likert scale >= 4, otherwise access motive dominant	binary

age are expected to have a positive effect on goal achievement and other outcomes. In regard to differences in the firms' approaches toward R&D, the variables **R&D intensity**, measured as the share of a firm's annual income (re)invested in R&D as average of the years 2007 and 2008, and **R&D breadth**, in terms of the number of R&D projects conducted within the time span from 2003 to 2008, have been integrated into the model. These two variables capture the depth and breadth of the firms' engagement and experience in R&D activities, both of which constitute indicators for the experience a firm has in conducting R&D. This experience is thought to be positively related to goal achievement and other outcomes. However, increasing breadth of R&D projects can also lead to smaller budgets per project. Thus, its net effect is not clear. A further variable served to cover the firm's general strategy toward inter-organisational co-operation. The variable chosen is the number of partners for co-operation in R&D in the period 2003 to 2008 (**network centrality**). This variable provides insights into the degree of embeddedness of the focal firm in inter-organisational networks. It captures the breadth of the co-operation portfolio and represents a proxy variable for the inter-organisational experience a firm can draw on. Again, while the level of experience is thought to exert a positive effect, a high degree of diversification might also exert a negative effect on the outcome of individual projects due to a too great dispersal of activities.

The second set of control variables turns to the case co-operation project itself. It first considers the variance in the length of the case co-operation projects (**duration**). Three categories, short-term (< 12 months), medium-term (12-36 months), and long-term (> 3 years) projects, have been defined. As the descriptive analysis has revealed that out of the three classes, only the latter two classes were used, a binary variable is created with zero for medium-term and one for long-term duration. It is suggested that with time, increasing proximity can be established between the partners (Simonin, 1999). However, long project duration might also have an ambivalent role: The longer the project, the more it can take a backseat compared to other daily business tasks or other projects. Thus, long-term projects need not necessarily imply more intensive and close relationships but might give way to distance-decay. The net effect of a project's duration is not clear. Second, the role of the **invention stage** has been discussed in section 4.6.1. Due to the differential characteristics of research versus development, particularly in regard to the risks of technical failure, difficulties to share new knowledge, control over the partner's behaviour and the design of work plans, it can be assumed that collaborative research is more prone to failure than collaborative development. However, also the counter-thesis has been formulated, which holds that development is more dependent on know-how which is even more difficult to be shared and combined in inter-organisational co-operation than know-why which is maybe more central in research. A binary variable has been created with one indicating a research project and zero a development project. Adhering to the first argument, the effect is thought to be negative. As last control variable, the **learning rationale** has been included. In section 4.6.2, a distinction has been made between projects which build on a division of labour where access to resources is the dominant motive for inter-organisational co-operation ('reciprocal learning') and projects which are initiated in order to learn from the partner and eventually absorb his knowledge and skills. As learning assumedly demands a closer integration of the partners and is more at risk to result in learning races and knowledge protection by the partners, projects which are driven by a learning intent might be more likely to fail their goals. Thus, the coefficient would be negative. An explicit learning intent has been defined as an evaluation of learning of greater than four on a scale range from zero (no learning intent) to five (high learning intent). Otherwise, the project is qualified as driven by an access intent.

Presentation and Discussion of Results

In a first series of regression models, the relationships between the independent variables and goal achievement as well as the other outcome categories were analysed. While goal achievement represents a global measure of the success of the co-operation project, the other outcome categories yield more detailed information on different effects from the respective independent variables.

Next to linear relationships between the variables, some non-linear effects were theoretically discussed. Specifically, an inverse U-shaped relationship has been proposed for the dimensions of institutional, technological and relational distance on the different success measures (hypothesis 2, 5 and 6). Thus, quadratic effects were included in the model for these dimension (Wooldridge, 2000).

The results of this first series of regression models are presented in table 8.21. The table includes the logistic regression coefficients for the independent variables of the different dimensions of distance and the control variables. Besides, it includes a model fit block which contains central statistical measures that characterise the quality of the model.[24] Before turning to the results for the different dimensions of distance, the next two paragraphs briefly discuss the model fit and the results in regard to the control variables.

Model fit

To begin with, the statistic sigma constant in table 8.19 is equivalent to the standard error of estimate in OLS regression. The value of .50 in respect to the dependent variable goal achievement can be compared to the standard deviation of the dependent variable which was .90. This result shows a substantial reduction of the variance in the dependent variable. Also the models in regard to the other dependent variables show a considerable reduction in variance with highly significant results.

Chi^2 represents the test statistic which probes whether at least one of the predicted regression coefficients is not equal to zero. Its interpretation is supported by the statistic Prob > Chi^2, which tests the null hypothesis that all of the regression coefficients are simultaneously equal to zero. The low values of this statistical size tell that this null hypothesis can be rejected at $p<.01$. The small p-values reassure that at least one of the logistic regression coefficients in the respective models is not equal to zero.

Lastly, R^2 corresponds to the global criteria of the goodness of fit in ordinary least squares (OLS) estimates, there indicating the amount of variance in the dependent variable explained by the model. It ranges between zero and one. The closer R^2 is to one, the larger the amount of variance in the dependent variable explained.[25] In the different models, R^2_{pseudo} mostly adopts a value of around .50 with a minimum of .36 in the inventive outcome category and .68 in the personal outcome category.

[24] For regressions based on maximum likelihood estimation, the standard regression diagnostics for heteroscedasticity and multicollinearity cannot be applied. In regard to issues of heteroscedasticity, a robust model was run and the respective results were compared, but didn't show any substantial differences. Furthermore, as Stata by default excludes variables in the case of high degrees of multicollinearity, which did not happen in any of the models, the results suggest that no exact multicollinearity between the variables exists. Likewise, parameter estimates for the different dimensions of distance do not change substantially if the control variables are excluded from the model.

[25] Stata by default calculates McFadden's R^2, which which was also used here. It is commonly referred to as R^2_{pseudo} and is computed in the following way:

$$R^2_{pseudo} = \frac{ln\mathcal{L}_{\prime} - ln\mathcal{L}_{\mathcal{K}}}{ln\mathcal{L}_{\prime}} \tag{8.9}$$

Table 8.21: The Impact of Distance on Project Outcomes (Tobit Regression)

	GOA	INV	STRAT	OP	PERS	REL
Geogr. dist.	-0.10	-0.18	0.26†	0.10	0.14	-0.14
Institut. dist.	1.92*	2.87	0.97	0.60	-0.37	2.47**
(Institut. dist.)^2	-0.42*	-0.59	-0.26	-0.15	-0.00	-0.60**
Organis. dist.	-0.02	0.09	0.02	-0.05	-0.15*	0.13
Strat. dist.	-0.22†	-0.07	-0.34**	-0.12	0.04	-0.14
Technol. dist.	2.12**	3.09**	2.49***	1.09	2.85***	2.29**
(Technol. dist.)^2	-0.49***	-0.60**	-0.48***	-0.22†	-0.55***	-0.41**
Relat. dist.	0.38	-1.18	1.89	3.86†	-1.22	-0.78
(Relat. dist.)^2	-0.02	0.21	-0.21	-0.49†	0.16	0.05
Firm Size	0.00*	0.00	0.00	0.00	0.00*	0.00
Firm Age	0.01	0.02	-0.05†	-0.02	-0.05*	-0.08**
R&D intensity	0.09	0.10	-0.14	0.09	-0.09	-0.02
R&D breadth	-0.13	0.30	-0.19	-0.04	-0.24*	-0.36**
Network Centr.	-0.12	-0.51*	0.39*	0.09	0.25*	0.40*
Duration	-0.23	0.32	-0.60**	-0.93***	-0.30†	-0.19
Inv. stage	0.53†	0.88†	0.73*	0.75**	0.92***	0.67*
Learn. rationale	0.19	0.47	0.09	-0.07	-0.08	-0.43†
Constant	-0.00	-2.85	-2.71	-5.23	4.27	1.34
Sigma constant	0.50***	0.66***	0.42***	0.46***	0.34***	0.47***
No. of cases	39	37	38	37	39	39
log-likelihood	-26.29	-31.98	-21.02	-21.73	-15.12	-22.89
Chi^2	43.68	35.67	49.24	34.93	64.66	51.38
Prob > Chi^2	0.0004	0.0051	0.0001	0.0064	0.0000	0.0000
R^2_{pseudo}	0.45	0.36	0.54	0.45	0.68	0.53

† $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

GOA = Goal Achievement; INV = Inventive Outcomes; STRAT = Strategic Outcomes; OP = Operational Outcomes; PERS = Personal Outcomes; REL = Relational Outcomes

Geogr. dist. = Geographic distance; Institut. dist. = Institutional distance; Organis. dist. = Organisational distance; Strat. dist. = Strategic distance; Technol. dist. = Technological distance; Relat. dist. = Relational distance; Network Centr. = Network centrality; Inv. stage = Invention stage; Learn. rationale = Learning rationale

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$\mathcal{L}_I$ stands for the likelihood that all coefficients except for the constant are zero and $\mathcal{L}_K$

The variances and marginal effects of each of the regression coefficients are presented in a comprehensive table in Annex C.

Control Variables

The regression analysis reveals that the effect of firm **size** is positively related to the level of goal achievement ($p<.05$) as well as the personal outcome category ($p<.05$). This finding supports the suggestion that larger firms are backed by higher resource endowments, which enable them to reach the goals of the co-operation project and which in turn contributes to higher levels of personal satisfaction with the project. Yet, size does not exhibit a clear relationship with respect to the inventive, strategic, operational and relational outcomes.

The **age** of the focal firm is however not significantly related to goal achievement, which also applies for the inventive and operational outcomes. Significant negative coefficients are found with respect to the strategic ($p<.10$), personal ($p<.05$) and relational ($p<.01$) outcome dimensions. Compared to older firms, it can be assumed that young firms put more weight on the pursuit of strategic goals and the establishment of networks, both of which might be important levers to substantiate the firm's future stability or growth. This weight attached to external ties might lead to a higher degree of motivation and commitment to the partnership, which seemingly also pays off in regard to higher levels in respect to personal-level outcomes. An alternative explanation is that young firms dispose over less experience in inter-organisational projects, thus lacking a direct benchmark for their evaluation.

R&D intensity as third control variable captures the amount of a firm's annual incomes which is (re-)invested in R&D. Surprisingly, the coefficients of this variable display no significant relationships. One explanation might be that the general level of R&D intensity is very high throughout the sample with the majority of firms centering their whole business model on R&D activities. Thus, differences in R&D intensities are primarily attributed to differences in the firms' hybrid business models, i.e., firms which pursue a hybrid business model often incur early revenues and thus display lower levels of R&D intensity. Being a relative indicator, it dispenses to recognise differences in the absolute budget for R&D or the overall number of staff

equals the likelihood of the estimated model. Although the interpretation of the R^2_{pseudo} differs from the R^2 in OLS regression, it generally holds that higher levels of R^2_{pseudo} are preferred to smaller ones (Kohler & Kreuter, 2008).

within R&D, which can be more decisive in regard to a firm's level of experience in R&D and internal knowledge breadth. Hence, the variable is a crude indicator for the firms' experience in R&D, particularly in the field of modern biotechnology.

The variable **R&D breadth** covers the number of R&D projects a firm pursued within the five-year period from 2003 to 2008. As a result, firms are expected to be more versed in conducting R&D projects, often across different topics. On the other hand, a higher number of projects might be accompanied by a lower allocation of resources to each project and the firm might be prone to fritter among different projects. From the empirical data, it has been revealed that R&D breadth is negatively related to the personal ($p<.05$) and relational outcome dimension ($p<.01$). These results support the second suggestion of a greater dispersal of time and energy across the projects, which leads to lower personal satisfaction and liabilities in relationship-building. In regard to the other outcome dimensions, no significant results have been revealed.

The variable **network centrality** captures the number of external R&D partners within the time period from 2003 until 2008. Implicit in this variable is the assumption of a higher level of experience in inter-organisational co-operation projects across different partners. On the other hand, the firm might divert too much energy to coordinate different external partners. In the regression analysis, a negative coefficient of the variable network centrality in regard to the inventive outcome dimension has been revealed ($p<.05$). This finding supports the suggestion that a high number of external partners might surmount the firm's capacity to exploit the full inventive potential of each partnership. Yet, the number of external partners exerts a positive effect on the realisation of the firm's strategic goals ($p<.05$), which supports the assumption of positive positional or relational effects of dense networks. A high network centrality is also positively related to the personal ($p<.05$), and relational outcomes ($p<.05$). Thus, firms which are experienced in a high number of external partnerships achieve higher levels of personal satisfaction and learning effects from these. Further, experience in relationship-building seems to be transferred to the focal co-operation project, which is displayed in a positive coefficient with regard to the relational dimension. This explanation however contradicts the hypothesis of a lower level of investment in each partnership as suggested above. Another explanation would be found in increasing returns to a beneficial network position, which attracts and supports new partnerships.[26]

Moreover, it turns out that a long project **duration** has a significant negative effect on the strategic ($p<.01$), the operational ($p<.001$) and the personal ($p<.10$) outcome dimensions. In regard to the first observation, it might be the case that strategic projects are more oriented toward short-term goals. The observed negative effect of a long duration on operational outcomes supports the suggestion that longer projects might suffer from being operated in a less stringent way. This explanation can also apply to explain the negative sign in regard to the personal dimension with long-term projects often floundering or the partners losing sight of each other.

In regard to the **invention stage**, it turns out that research projects compared to development projects display significant positive effects in all outcome dimensions. This result is counter the initial expectations which assumed collaborative research projects to be more difficult and risky compared to development projects. Yet, it turns out that co-operative research projects more often realise their goals ($p<.10$), achieve higher inventive outcomes ($p<.10$) and at the same time contribute to realise strategic aspirations ($p<.05$). Moreover, co-operative research projects tend to perform better in regard to their compliance with budgets and time lines ($p<.05$), lead to personal satisfaction and high learning effects ($p<.001$) as well as a positive outcome in regard to relationship building ($p<.05$).[27]

The results in regard to the **learning rationale** are less pronounced with only one significant relationship. It turns out that learning from the partner is negatively related to relational outcomes ($p<.10$), as manifest in lower scores in regard to the establishment of trust, a long-term relationship and access to other partners. Thus, the motivation to learn from – or even out-learn – the partner has a negative

[26] The low number of significant relationships, particularly in regard to the first four variables (size, age, R&D intensity, R&D breadth) might be traced back to the nature of the variables which in essence are one-sided. They capture the characteristics of the focal firm, neglecting the characteristics of the partner. Yet, their omission does not lead to substantial changes in the coefficient parameters of the remaining variables.

[27] The good operational performance of co-operative research compared to co-operative development projects has been explained by some interviewees who reported that within early research or validation projects, a fixed amount of resources is allocated after which the project either proves worthwhile to be continued or else it is discontinued. Co-operative development projects are by contrast characterised by higher investments and higher values at stake which prevents the partners from giving up. Besides, it has been stated that the time it takes to realise a prototype or get a process started is often initially underrated.

impact on relationship-building as well as on the development of the overall network.

In the following, the analysis turns to the main explanatory variables of distance. For each dimension, the results of the quantitative model are presented. Their discussion and interpretation then draws on the large qualitative material which was collected within the interviews and systematically analysed.

Geographic Distance

It has been argued in section 4.4.1 that geographic distance, although offering the potential to leverage novelty or mobilise the best partner, has a negative impact on the ability and motivation of the partners to share knowledge. Despite advances in the tools for distance communication and a dense global infrastructural net supporting business travel, it has been suggested that geographic distance negatively affects the frequency and quality of interaction between the partners through a switch to less rich communication media and the resulting higher costs of interaction. This has been assumed to hamper knowledge sharing and thus exert a negative effect on goal achievement, which is foremost driven by deficiencies in the project's efficiency (operational outcomes); a reduced learning potential coupled with greater personal strain (personal outcomes), and difficulties in relationship-building together with lower levels of trust in the partner (relational outcomes) (hypothesis 1).

However, the results of the regression analysis in table 8.21 suggest that geographic distance is no strong direct predictor of the outcomes of a co-operation project across the dimensions. The signs of the coefficients of geographic distance in respect to goal achievement and relational outcomes are negative; however they are not statistically significant. With respect to operational outcomes, the regression coefficient is even positive, but likewise not statistically significant. The only significant coefficient is a positive relationship between geographic distance and the realisation of strategic outcomes ($p<.10$). One explanation for this finding might be that international partners are sought in order to realise specific strategic goals, such as accessing markets, setting (de facto) standards, shaping market structures or enhancing the firm's global visibility and reputation. Moreover, the new or enhanced products, processes or services that result from the co-operation project often mark an important step in the strategic development of the firm.

All in all, hypothesis 1 on the negative effect of geographic distance on goal achievement, efficiency, personal outcomes and relationship-building needs to be rejected.[28] The inclusion of the qualitative data provides a more detailed picture of the actual impact of geographic distance within inter-organisational co-operation projects from the interviewees' point of view.

To begin with, two central **moderating variables** were identified from the interviews: the perception of geographic distance and time distance or the accessibility of the partner. First, it came out that firms differ in their perception of geographic distance and thus their sensitivity to engage in co-operation projects with geographically distant partners. While the majority of interviewees downplayed geographic distance as a decision variable, other firms, particularly less experienced and more regionally embedded ones, admitted at least a trade-off between geographic propinquity and the quality or availability of a partner. For example, one interviewee from a small diagnostics company that was firmly anchored in its home region, both in its business and private networks, admitted that

> *'every geographic separation is a compromise that has to be justified by other things, the quality in other points of the partner.' (IP10)*

Second, the impact of geographic distance was centrally moderated by time distance and the accessibility of the partner. This is expressed by one interviewee, for whom it matters

> *'whether the partner is six hours, three hours, or just one hour away. For me, geography is not relevant, but time and complexity.' (IP7)*

Likewise, another interviewee underscored that *'direct flights are everything' (IP30)*. Particularly when people from management level were involved, the need for stopovers

[28] One explanation for this result might be found in the design of the study. As the study concentrates on *international* co-operation projects, the minimum geographic distance of the case co-operation projects is 190 kilometers. This distance already prevents spontaneous or chance encounters, but necessitates scheduled meetings. Turning to the distance-decay model presented in section 4.4.1, the sample projects might be located at the asymptotically descending branch of the function, which implies that no strong effect of variations in geographic distance is discernible any more. Extending the sample to inter-organisational projects between partners located in the immediate vicinity might yield different results in regard to the effect of geographic distance.

to change flights was evaluated as a no-go criterion, raising the opportunity costs and lowering the motivation to travel. Even more, when the site of the firm itself or that of the partner was located far from the airport, this was perceived as a hindrance for international co-operation. Next, the firms underscored the need for a shared time window for electronic communication. Thus, the reach of international co-operation projects was frequently delineated by a radius of a maximum of six hours' time difference as well as a transport net of direct flights.

Turning to the **effects** of geographic distance, most interviews again downplayed any negative effects. By contrast, the contribution of the partner was stressed and the interviewees underscored the quality of the partner's resources: *'selection of the best' (IP10)*, *'selection on the basis of competencies' (IP43)* or the desire to integrate a *'famous partner' (IP39)* were often underscored to dominate geographic considerations.

Correspondingly, the majority of interviewees did not address any disturbing effects of geographic distance. However, some interviewees admitted that *'the frequency of meetings is naturally significantly lower than desirable' (IP11)*.

Thus, all interviewees were asked to indicate how frequently the partners had met in person on different occasions during the project (table 8.22). On a scale from 1 (very rarely) to 5 (very frequently), face-to-face project meetings ranked highest (μ=3.2, σ=0.85), followed by on-site demonstration (μ=2.5, σ=1.36), informal meetings at other events (e.g., conferences; μ=2.1, σ=0.75), temporary personnel exchanges/secondments (μ=2.0, σ=1.39) and permanent collocation of the team (μ=1.5, σ=0.86).

Across the cases, a number of two to four face-to-face project meetings annually were reported.[29] Only one interviewee from a small firm reported that they had never met their US partner face-to-face during the whole project (which lasted for more than one year); primarily for cost reasons. Thus, pure virtual teams were the exception, although the frequency of face-to-face interaction was perceived as reduced through geographic distance. Moreover, closer, more extended forms of interaction, such as personnel exchanges/secondments or a permanent collocation

[29] The bivariate correlation coefficient between the frequency of face-to-face contact and both the kilometric distance as well as the construct geographic distance revealed a negative sign; however there was no significant relationship.

Table 8.22: Frequency of Face-to-Face Interaction

Frequency of face-to-face interaction	Mean	Std. Dev.
Face-to-face project meetings	3.2	0.85
On-site demonstration	2.5	1.36
Informal meetings at other events (e.g., conferences)	2.1	0.75
Temporary personnel exchanges/secondments	2.0	1.39
Permanent collocation of the team	1.5	0.86

1 := 'very rarely'; 5 := 'very frequently'

of the team, were rarely used. Only in very few cases could the firms expend one employee who spent an extended period with the partner. Interestingly, these more intense forms of interaction, particularly personnel exchanges/secondments was well as on-site demonstration, also display a high variance in the data indicating differences in the use of different means among the case co-operation projects.

For most of the regular interaction, the partners resorted to electronic means of communication. Asked about the frequency of use of different communication media on a five-point scale, with the end points 1 (very rarely) to 5 (very frequently), the interviewees claimed that they resorted in descending order to email (μ=4.6, σ=0.57), telephone/teleconference (μ=4.1, σ=0.95), shared databases (μ=2.8, σ=1.44) and videoconferencing (μ=1.5, σ=0.95) (table 8.23).

Table 8.23: Frequency of electronic interaction

Frequency of electronic interaction	Mean	Std. Dev.
Email	4.6	0.57
Telephone/teleconference	4.1	0.95
Shared databases	2.8	1.44
Videoconferencing	1.5	0.95

1 := 'very rarely'; 5 := 'very frequently'

This pattern shows that less rich means for communication (email, telephone/teleconference) take precedence over richer means of electronic communication, particularly videoconferencing. However, there is again variance among the case cooperation projects. In particular, the benefits of videoconferencing were disputed, with a large share of interviewees rejecting them entirely. The main reason for this rejection were an insufficient quality in transfer rates coupled with the high costs of professional equipment, particularly for small firms. The highest variance was revealed for the implementation of shared databases for data sharing, where most of the interviewees resorted to emails to exchange the latest data.

Turning to the effects of lower incidences of face-to-face communication and a switch to ICT for day-to-day interactions, the opinions on the substitutive power of ICT again varied among the interviewees. While again the majority of interviewees did not report any difficulties in interaction through virtual communication, others adopted a more critical stance:

> *'I always have the hope that it works via electronic media, but I always get the impression that it is not the same. One cannot substitute direct contact with electronic media ... [Further,] the free or cheap available video-conference tools are poor-quality. They don't help. And those big video systems, which we saw at our large partners', ... those are beyond our financial capacities.' (IP11)*

One interviewee assumed that there is always certain *'room for interpretation' (IP7)*, which is hard to rule out across geographic distance when one does not see the facial expressions and gestures of the partner. Some reactions that were perceived as important feedback mechanisms got lost in communication. Thus, some interviewees recognised the loss of contextual messages in electronic communication. Likewise, the opportunities for learning from the partner were perceived as limited at geographic distance and through ICT. In this case, more intensive interaction over extended time periods on site were considered necessary.

Moreover, some interviewees reported that they had the feeling that information had been passed on selectively and that they had not been properly informed about the project's state and progression. One interviewee experienced that

> *'the quality of communication was sometimes not as good. One realises, had we met half a year earlier, things could have been settled faster. Some things remain left over or there are misunderstandings. ... Sometimes, many, many things happen in a very short period of time on one side and the other misses this. ... One could of course write everything in an email, but then it also often gets lost. ... Myself, I notice that I have loads of information and when one talks about it some time later, and refers to some email, me or the partner don't remember anything about it.' (IP11)*

Thus, important information from the recipient's point of view was sometimes felt to have been missed out or distorted, leading to misunderstandings and irritations. Due to the punctuated nature of communication, coupled with the often unpredictable paths that R&D activities take, where adaptations from plans are necessary or new ground broken, some interviewees did not feel well informed by the partner. Hence, geographic distance was reported to lead to a lack of transparency and information discrepancies between the partners, and eventually delays in the project's schedule. One interviewee reported that

> *'sometimes we couldn't understand why something was delayed. We didn't figure out everything. Then it does play a role – I mean geography and culture.' (IP22)*

This higher degree of intransparency in regard to the partner's actions, as well as higher investments in planning and co-ordination, was reported by some interviewees, who also felt a loss of control when the partner escaped their sphere of influence. It becomes more difficult to monitor the partner and constantly align interests and incentives when the partner is out of sight. This is expressed by one interviewee in the following quote:

> *'I am of the opinion that geographic proximity is extremely positive. As soon as one cannot walk across the street and step on the other's feet because nothing is happening, but he entrenches himself behind an email or the telephone, this can be a problem. The time we lost, because the people are living further away ..., where one cannot just pass by, is immense. This is counter-productive. If you want to get*

> *things done, it is easier when one can simply walk across the street.' (IP12)*

Similarly, another interviewee perceived that projects were prioritised according to the geographic reach of the partner. However, this was foremost recognised as a problem at critical junctures of the project when there was a heightened risk of escalation or conflict between the partners, rather than in the daily operation of the project. In this vein, accessibility was also perceived as a quality attribute of the partner and thus as partner-dependent.

A number of interviewees recognised that it was difficult to establish a relationship with the partner leading to the requisite level of obligation, personal affection, trust and commitment. Thus, one small firm considered the greatest challenge from geographic distance to be

> *'that one cannot build a relationship. Or else, it is difficult to establish a true relationship.' (IP15)*

Primarily in those cases where firms explicitly aimed to enter networks or establish enduring ties beyond the focal project, they reported to be disappointed with the results.

Taken together, two moderating variables were central: the **perception** and the sensitivity of the firms toward geographic distance, as well as the **accessibility** of the partner and time distance, which proved to be more pivotal than geographic distance in a metrical sense. Provided this was in place, the majority of interviewees downplayed the impact of geographic distance for the inter-organisational project; highlighting instead the **quality** of the partner's resources. Those who addressed liabilities of geographic distance doubted the effectiveness of electronic communication, leading to higher incidences of **misunderstandings**, **irritations** and **uncertainty**. Moreover, **learning** from the partner demands more extended times of close personal interaction with the partner. Some interviewees experienced a higher degree of **intransparency** and **delays** and felt a **loss of control** as the partner escaped their sphere of influence. Besides, liabilities emanated from geographic distance in regard to **relationship-building**. Only two very small firms addressed increased **costs** in international co-operation as an additional burden.

Thus, efficiency of and personal satisfaction with the project, as well as trust and relationship-building, as proposed in hypothesis 1, have been reported to have sometimes suffered from geographic distance between the partners. However, these were rather single incidences and not addressed by the majority of interviewees.

Institutional Distance

In section 4.4.2 it has been suggested that institutional distance, by contributing different scientific and technological strengths and diverse views to a project, can yield complementary or alternative insights to achieve a project's goals and to realise highly inventive outcomes.[30] Differences in technological strengths and perceptions can lead to a greater variety of ideas and approaches, which is thought to be conducive to invention. However, higher levels of institutional distance – particularly cultural and language differences – have been suggested to hamper the process of knowledge sharing as well as the motivation to do so in the light of increasing relational risks. Together, this argument suggested a positive relationship between institutional distance and co-operation outcome up to a threshold level, after which the potential benefits eventually turn into liabilities. The resultant function is an inverse U-shaped relationship between institutional distance and goal achievement. Initial positive effects are also expected for the inventive, operational, personal and relational dimensions, whereas the negative effects of high levels of institutional distance are thought to be particularly pronounced in regard to the operational, personal and relational dimension, eventually outweighing the suggested benefits (hypothesis 2).

Across most of the outcome dimensions, the results of the regression analysis provide support for the hypothesis of an inverted U-shaped relationship between institutional distance and the respective outcome variables (table 8.21). Except for the personal outcome dimension, all coefficients of institutional distance are positive in the linear term and negative in the quadratic term. However, statistically significant relationships are found only in the dimensions goal achievement ($p<.05$) and relational outcome ($p<.01$). The first result suggests that, overall, institutional distance has a positive effect on realising the goals of the project, as long as these differences do not exceed a level after which they turn into a burden that negatively affects the overall

[30] It has been argued that geographic distance itself does not necessarily yield novelty, but that it is rather institutional distance that contributes diversity of ideas and approaches as well as complementary scientific or technological insights.

co-operation project. Likewise, institutional distance can exert a positive effect in regard to relational quality and can serve as a stepping stone to enter a specific network. However, beyond a threshold level that supports relationship and network building, the effect turns negative. This is in line with the suggestion that there are greater problems in establishing a close and trustful relationship when high levels of institutional distance separate the partners.

All in all, hypothesis 2 is largely supported by the regression results. It seems that initial levels of institutional distance contribute to goal achievement and a favourable relationship between the partners up to a threshold level when the relationship can become too complex to handle. In respect to the other outcome dimensions, particularly the inventive, operational and personal dimensions, the coefficients display the expected signs, but the data shows a less uniform pattern across the cases to yield statistically significant results.

This is also supported by the qualitative data. Again, a number of **moderating variables** emerged from the interviews. First, interviewees underscored what could be associated with a global epistemic community that shares a common spirit as well as basic approach and methodology. Second, the high internationality of the biotechnology business, marked by a high international composition and experience of the firms, facilitates international co-operation. Third, a shared lingua franca (English) supports communication in the absence of a shared mother tongue. Lastly, primarily within Europe, institutional security warrants the enforcement of ownership claims which decreases the perceived risks from international co-operation.

In most of the cases, the contribution of the partner was found in a very narrow scientific or technical field, which was often characterised as *'novel' (IP20)* or *'unique' (IP19)*. In three cases, the choice of an institutionally distant partner was accompanied by the desire to enter a new market or a scientific network, particularly in the Japanese and Egyptian cases. Thus, a highly specialised epistemic tie was forged across the globe between two partners who shared the will to jointly solve a technical problem, advance the state of knowledge, or realise a new or enhanced product, process or service. This joint spirit, backed by a common scientific approach and mutual respect for the expertise of the other that defines an epistemic community, was suggested to level out cultural noise in the relationship – at least to some extent. This is illustrated in the following quote from a small biotechnology firm that is experienced in co-operation projects with partners from various countries and nationalities:

> *'We have created something exceptional within the natural sciences during the last fifty years. That is, that mutual understanding aside from any cultural context is possible, because we are strongly driven to scientifically test a hypothesis. This procedure is quasi-worldwide the same when moving within science. This is why, aside from their cultural context, the people understand each other pretty well.' (IP7)*

Thus, regardless of institutional affiliation, a common denominator was found in regard to basic scientific approaches and principles that allowed for communication and co-ordination across cultural distance. It was commonly perceived that this similarity and feeling of belongingness to one research community levels out cultural differences between the partners.[31]

Next, some interviewees evaluated an on average high degree of internationality of the firms as facilitative for international co-operation. The firms were often composed of scientists from different nationalities. In addition, a large number of the scientists, particularly those in the higher echelons, reported that they had spent some time abroad during their training or professional career. Hence, the level of international experience of those topically involved in inter-organisational co-operation was generally high. One interviewee noted:

> *'From my perspective, it is less the cultural difference. It is more important to have this international imprint. One needs to know how to deal with different cultures. ... We are very international; we all lived in America or in different countries for a while, and speak different languages ... I myself worked [in America] for a while.' (IP44)*

Vice versa, interviewees reported that their partners' teams (particularly in the US) were often composed of people of different nationalities. Thus, the dominant culture of a country was perceived as a poor indicator of the cultural affiliation of the

[31] This insight conforms to what Knorr Cetina (1999) describes as 'epistemic cultures'. A number of interviewees underscored that an epistemic community shares a specific culture, underpinned by a highly specific body of knowledge and approaches, that overrides the effects of national culture.

people involved in the co-operation project. Their international experience, cultural values and mentalities – at least in a science-driven, global field such as modern biotechnology – often deviate from the dominant culture of a country. Hence, the relevant level on which to judge the compatibility or comparability of values is more often attached to individuals than to a firm's location. It was generally stressed that comparable mindsets exist within different cultures. One firm that was experienced in collaborating with partners from different nationalities expressed:

> *'I believe in every nation there are people who find each other and who share a common set of values – in some nations more than in others. Thus, in the end, the dimension of nationality does not count for me.' (IP7)*

Generally, the impression was gained that firms search for partners that resemble themselves in values; who displayed *'the same wavelength' (IP27)* independent of their national origins. This resemblance was rooted in individuals and the individual or organisational imprint rather than national culture.

This high international imprint of biotechnology firms is further backed by the common scientific language English, which prevails in scientific literature as well as, to some extent, within the companies. Some interviewees stated that due to the great diversity in the cultural composition of their teams, they refer to English as their prime organisational language, which is mirrored in the following quote:

> *'Our firm's internal language is English anyway. ... All the correspondence, everything is done in English.' (IP26)*

Hence, differences in mother tongue were largely not perceived as a problem, particularly as a large share of collaborative ties reached out to US partners. As most scientific literature is in English, most interviewees reported that technical communication was barely affected by language differences. Moreover, particularly within Europe, increased relational risks, in particular the risk of knowledge misappropriation through the transcending of institutional boundaries, were generally not perceived. The view dominated that risks could be hedged contractually and ownership rights enforced.

However, it has been observed that the perception of institutional differences and the effects thereof differ considerably in line with the personal experience, familiarity and proficiency the firm had gained in regard to a particular country. The firms in the sample displayed differences in regard to the international composition and experience of their own as well as the partners' team members, and some **effects** of institutional distance were reported.

In regard to language differences, one interviewee critically acknowledged that

> *'language differences, also in the technical-scientific discourse, are underrated by most' (IP18).*

Another interviewee substantiated that

> *'in technical terms it is easier to retrace whether the partner comprehended everything than in cultural terms' (IP11).*

Thus, some interviewees felt that the social dimension of the relationship suffered more from language differences than the scientific-technical interaction between the partners.

General institution-specific differences in behaviour, attitudes and mentalities of the partners were mostly admitted to some extent, although their effects on the project varied. For example, one interviewee experienced that

> *'Swedish people are generally cautious at the beginning. This slowed down the project at first. The longer it goes, the better it works. ... [However,] Swedes are Europeans. This is generally innocuous. They are similar to us in regard to their behaviour and values. They are surprisingly similar. One may not underestimate cultural distance. One is likely to underestimate this. Also Americans differ, even though one first doesn't believe this.' (IP39)*

Thus, the interviewee admitted a larger customisation time. Another German firm that maintains a collaborative partnership with a US partner reports that

> *'Americans are very quickly very enthusiastic. From their point of view, a project is often brilliant, whereas we Germans are slower to attach a seal of quality to it. Some things are perceived as fin-*

> *ished what is not yet so far. You have to make a discount. Even more: for them, a patent application is often equal to a final product. … However, when Americans apply for a patent, it is often based on speculation. This can become critical when data has to be filed during the provisional phase. … There is often a gap. The largest difference between Americans and us is their enthusiasm. They perceive things as complete and "jump on the next target", even though the first is not yet fully valid.' (IP3)*

However, these differences had been anticipated by the focal firm, which was experienced in German–US co-operation projects. In response, the focal firm implemented a governance mechanism based on a graduated price structure: dependent on the stage of the project within the proof-of-concept, other conditions and prices applied according to a fixed scheme. The goal of this highly formalised governance mechanism was that *'we aimed to not endanger our personal relationship' (IP3)*, prevent disputes and at the same time maintain creativity by not intruding directly into the research process. In other cases, high degrees of experience, particularly with US or European partners, helped to anticipate and mediate potential frictions expected from cultural differences in advance.

The international experience of the firms was primarily European and US-centric – countries generally rated by the interviewees as institutionally proximate to Germany. Cultural and linguistic differences became more critical when larger differences and lower levels of experience came together. Particularly with the emergence of new players from more institutionally distant countries, institutional differences reached a new level and experience levels were generally lower. This was acknowledged by interviewees who reached out to countries that they characterised to be marked by higher levels of institutional distance; primarily Egypt and Japan. For example, one interviewee reported on a German–Egyptian development co-operation project:

> *'Yes, we had language problems [in Egypt]. This depends on with whom one interacts. On the management level we used English. Then communication is possible. However, on site, the teams, the group leaders, they don't speak English anymore.' (IP22)*

Thus, misunderstandings or irritations due to linguistic differences, particularly with increasing divergence in the origin of the languages and differences in the mastery of English, were perceived as being more disturbing in co-operation with institutionally highly dissimilar partners.

Next to linguistic differences, some interviewees found that it took time to become accustomed to different cultures. This was reported by one firm that aimed to enter a Japanese research community via a co-operation project with a local Japanese firm:

> *'Japan is more difficult in terms of communication. ... Many Japanese don't speak proper English and one has to be prepared for differences in mentality. One first needs to reach this step to cope with issues of mentality. This is more difficult. We also had seminars on behavioural issues in regard to Japan before, but this again has to be adjusted.' (IP27)*

Other interviewees who were experienced in German–Japanese co-operation projects observed differences in roles; for example, the role of women and men in a group. In one German–Japanese co-operation project, the interviewee observed that, although the project leader was a woman, every time he addressed her, he got an answer from her male colleague. These differences in roles and authorities were initially irritating and had to be learned first. Becoming accustomed and establishing mutual respect – even if contrary to one's own convictions – was thought to be an issue here. The interviewees stressed the amount of time that it took to become accustomed to deviating views, attitudes and mentalities. Moreover, it was noticed in one case that the partners reacted by devising a more stringent division of labour between the partners, thus aiming to reduce the need for close integration of and frequent communication between the sub-teams as far as possible.

One interviewee made an interesting point in regard to the emergence of conflict in inter-cultural interaction when high levels of institutional distance interfere. He observed that both partners adjust their behaviour based on the assumption of differences. Hence, both partners acted on stereotypes of themselves and the other and altered their natural behaviour to an extent that eventually created problems in the relationship.

> *'This is a cultural metamorphosis that happens in the host country. One changes as one thinks one needs to adapt and act differently. Moreover, one is often not aware of this and wonders why problems occur.' (IP7)*

With increasing levels of institutional distance, relational risks were again addressed, and the interviewees reported that the contracting phase in particular had been more intense, and loose arrangements were perceived as risky. This is captured by the following quote:

> *'Theoretically, our partner could have been in Japan, too, but then it would have "hurt" more. First, it takes longer with the contract negotiations. In this case, I could not only have said "We will fix a formal contract as soon as it becomes serious", but also needed to be aware that I would have to settle everything right from the start.' (IP37)*

Some interviewees who were experienced in co-operation projects with Asian countries, particularly China, perceived a threat that those countries were pursuing a strategy of unilateral knowledge drain. The interviewees felt there was an imbalance in the contribution of the partners and a risk of knowledge misappropriation by the partner. This eventually led to a general pullback by one German firm from transactions with Chinese partners. Thus, there was a general decrease in trust, both behavioural and institutional. In case institutional differences exceeded certain levels, the complexity and perceived risks within inter-organisational co-operation rose, and the motivation and openness decreased.

Thus, according to the experienced interviewees, becoming familiar and proficient in a highly different country necessitates a higher investment and a long-term view and resilience that must be justified by the expected rewards. Correspondingly, one interviewee from a small biotechnology firm who was experienced in collaboration with Chinese partners recommended that firms should

> *'reflect this clearly in advance, as money invested in India or China can be more expensive than an investment here, unless you have a wise reason why to do it in China.' (IP7)*

Smaller firms in particular were perceived as prone to relational risks. Having fewer resources to absorb losses, their investments were seen as more critical. Collaborating with institutionally highly distant partners was suggested to take more time, with more frequent misunderstandings and lower levels of transparency as compared to collaboration projects with institutionally proximate partners. On the other hand, investments in partnerships with organisations from newly emerging countries were perceived as a potential must in the future. Thus, the interviewees agreed that these challenges would become of great importance for them in the near future.

Taken together, the shared spirit and cohesion as well as shared basic approaches and principles as found in **global epistemic communities**, the **international experience** of firms and individuals (international 'imprint') backed by a shared **lingua franca** and existing **meta-institutions**, such as the EU, are key moderating variables. Thus, some interviewees praised the **new insights** they had gained from the relationship. However, with rising degrees of institutional distance, lower degrees of experience, language proficiency and legal enforcement security, this potential can be clouded by **misunderstandings**, **irritations** and **misappropriation concerns**. One interviewee stressed a metamorphosis (cultural adaptation based on assumption of differences/stereotypes) that he observed in interaction with culturally distant partners. According to the interviews, interacting with institutionally dissimilar partners necessitated an increased allocation of **time for customisation** and trust-building.

Thus, the inverted U-shaped relationship between institutional distance and different outcome dimensions has generally been confirmed by the qualitative insights. In particular, it seems that – although not an overriding effect in the overall sample – high levels of institutional distance were at times accompanied by higher operational and personal strain for the partners.

Organisational Distance

Next, organisational distance – defined in section 4.4.3 as differences in the 'rules of the game' at the organisational level – has been included in the regression model. Drawing on Nooteboom (2009), a difference has been made between deep-level structures, such as the organisation's self-perception and culture, and surface-level regulations, as manifest in the organisation's structure, its routines and scripts. It has been argued that these differences could be a source of friction between the organisations, both in respect to the alignment of goals, incentives and work processes, and in regard to knowledge sharing, with each organisation having developed its own codes, context and meanings. Motivational backlashes such as 'not invented here' or 'not sold here' syndromes have also been discussed within this dimension. Together, a negative effect with increasing levels of organisational distance on goal achievement was hypothesised, particularly driven by reductions in regard to the efficiency of (operational outcomes) and the team members' satisfaction with (personal outcomes) the project (hypothesis 3).

These suggested negative effects are only partially supported by the regression analysis (table 8.21): only the negative relationship between organisational distance and personal outcomes could be statistically confirmed ($p<.05$). This finding suggests that higher levels of organisational distance result in a negative perception of the co-operation among those who are involved in the project. It leads to higher levels of dissatisfaction, lower degrees of enjoyment of the co-operation, and lower perceived learning effects. Thus, the effects are mostly of a motivational nature. Overall, a high degree of variability exists in the data and hypothesis 3 can only be confirmed in regard to the personal dimension.

Also qualitatively, the opinions about the effects of organisational distance diverged among the interviewees. Most generally, the majority of interviewees acknowledged differences in the structure, organisation and organisational culture of their partners, which was foremost evident in firm–university collaborations or when larger size differences existed between the partner organisations (see table 8.14).

From the interviews, again three **moderating variables** have been identified: a shared scientific approach in biotechnology R&D; the common organisational form around (flexible) projects, and high degrees of experience in or with other organisations, particularly universities and large firms.

Thus, some interviewees stressed that scientific work generally shares a common scientific approach, which is driven by the basic quest to set up and test hypotheses. Thus, one interviewee noted that

> *'within scientific work there is only one approach. And this was identical.' (IP5)*

This shared scientific approach yields two effects: first, the self-perception and culture of the scientists was reported to provide a stronger basis for similarities and mutual identification than organisational boundaries, with scientists representing the in-group, both within as well as across organisational boundaries, while other functional specialties were rather considered as the out-group. Second, R&D in biotechnology was reported to follow certain operational steps that are shared by those active in the field. These shared proceedings, particularly when it comes to joint development activities that tended to be generally more pre-structured than joint research activities, helped to co-ordinate work across organisational boundaries. It turned out that some partners, despite considerable differences at first sight, were perceived to resemble each other in their basic cultures, routines and approaches as well as in their work organisation. In justifying his choice for one large partner, one interviewee explained

> *'[The partner firm] is still a biotechnology firm – they retained their research spirit, the way to the CEO is short; it is a scientifically driven firm.' (IP44)*

Closely coupled is a second moderating variable, forwarded by some interviewees, which is that research as well as development is largely organised in smaller units, mostly around flexible, temporary projects. These share basic structures, dynamics and approaches, which helps the partners to co-ordinate work flows and to identify with each other. Generally, these projects displayed a hub structure, with one lead scientist or project leader heading a team of scientists and technical assistants. These compatible functional structures on each side increased transparency and smoothed communication, co-ordination and integration across organisational boundaries. Moreover, the scientists, even in small firms, were to some extent used to adapting quickly to changing teams.

As a third moderating variable, some interviewees explained that they had expected organisational differences between the partners and anticipated them from the start of the co-operation project. The large majority of the employees in dedicated biotechnology firms are scientists who had had a scientific career at a university before joining or even founding a firm. In addition, some of the interviewees were also experienced in working for large multinational firms. This experience helped them to anticipate the challenges ahead and make provisions for them. This was clearly expressed by one interviewee who reported on co-operation with a university group

> *'Both sides [the focal firm and the university partner] knew this [the structural and organisational differences between the partners] before. We both anticipated them.' (IP10)*

However, this expectation of differences built on ex ante categorisations into typical characteristics of firms versus universities or small firms versus large firms. While these categorisations helped to anticipate organisational differences, they also acted as a cognitive boundary separating the sub-teams with strong prejudices in regard to work styles and aspirations. Thus, there were both a good and a dark side to these salient differences.

Moreover, some interviewees reported differences that had disturbing **effects** on the co–operation, particularly when these differences were not expected or salient prior to the co-operation.

First, some interviewees reported diverging goals that led to disagreement and irritations in some projects. These problems were particularly pronounced in firm–university projects, where some interviewees reported disagreements and conflict. This is illustrated by the following quote:

> *'A university group has entirely different goals. It cannot comprehend the goals of a firm and its priorities. And the other way round, of course. This led to problems. If, for example, the academic partner wants to solve the problem fundamentally ... but our customer wants to have a solution in two weeks, that is, a quick solution ... This is a point where we experienced a lot of disagreement.' (IP11)*

Differences in goals and incentives were not only attributed to universities. In one firm–firm co-operation, organisational differences were less obvious, more subtle and not expected prior to the commencement of the joint research project. They only appeared during the course of the co-operation. The interviewee reported that:

> *'They [the partner] work completely differently. They work tightly toward specific goals, toward pre-defined targets, because they receive a flexible income component that depends on the achievement*

> *of these goals. This is not so pronounced here. ... Before milestone payments were due, the largest failures were sold as the largest successes. ... You couldn't come near them any more with rational arguments.' (IP38)*

In this case, the partners' different reward structures resulted in incompatible incentives. While one firm was oriented toward long-term goals, the other sought short-term successes that would have a positive effect on an individual employee's payroll. Consequently, quick solutions were sought and communicated as successes, which was counter to the vision and orientation of the focal firm. The joint co-operation project eventually failed, not least because the firms did not manage to converge their incentives and styles and come to mutually compatible solutions.

Moreover, some interviewees reported differences in work organisations, schedules and time lines. This resulted in frequent (re)negotiations and led to delays and dissatisfaction – as expressed in the following quote from one interviewee who was generally disappointed and frustrated by his experiences in academic collaboration:

> *'Very few of our academic collaborations were successful.... one lets things aside, often loses interest or the post-docs leave, the graduates or doctoral students finish and then they are not interested any more. This is very, very difficult in scientific collaborations.' (IP15)*

Next to differences in goals, incentives and the organisation of work, fluctuation of personnel and changes in structure (which is seen as more prevalent in universities as well as in large firms compared to small and medium-sized biotechnology firms) is perceived as problematic within inter-organisational co-operation. In this vein, one firm reported on a co-operation project with a multinational partner:

> *'His [the partner's] organisational structure is changing constantly. From more centralised to more decentralised. Also the decision-makers have changed frequently during the last three years, which had an impact on the project work. As our partner's headquarters are located in the US and we collaborated with his European subsidiary, the whole collaboration was very complex and difficult. The overarching strategic direction came from the US, but they were not*

> *involved in the project. This made the co-operation very cumbersome.' (IP26)*

In this case, the large partner, after another change in management personnel and strategy, eventually lost interest and abandoned the co-operation project with the focal firm. Two other interviewees had the experience that shifts in personnel led to changes in the priority attached to certain projects, repeated investments in relationship building, as well as a general lack of stability of the co-operation. These circumstances were perceived as being beyond the influence of the focal firm, as they couldn't be ruled out contractually or sanctioned by any means.

In addition, with higher degrees of structural incompatibilities, communication structures as well as responsibilities were less aligned and eventually unclear, leading to intransparencies and a lack of contact people. While this was suggested to be less of a problem in 'good times', it can pose a problem in the case of conflict.

> *'[Here in-house,] a project leader and an escalation manager are nominated. Within the university, this is one and the same person. The professor is at the same time project leader and escalation manager.' (IP22)*

Incongruences in functions and structures were eventually perceived as missing, particularly in the case of conflict. Primarily in university co-operation, many different functions and authorities are ascribed to one and the same person, the professor of the specialty.

Moreover, organisational differences, particularly in regard to the structure of the partner, led to friction and a protracted process of contract negotiations.

> *'In the end, we dealt with one institute or one specific research group; however, in respect of legal aspects, the pace of co-ordination, for example when contracts need to be signed, we deal with the administration of the whole university ... When we have a contract with the UK and send it to them, then there is first the legal department of the university, which works on it, then after three weeks they have a further query ... If we make an agreement with another*

> *small firm in the size of [our firm], then the CEOs come together, discuss all the issues, and then the contract is signed.' (IP37)*

According to the majority of interviewees, however, while this was perceived as arduous in the contract negotiation stage, the phase of operating the contract itself was not directly affected.

In three cases where small firms were engaged in co-operation projects with large multinational firms, they experienced negative encounters as described in the literature by the expression 'not invented here syndrome'. The firms were initially confronted with a rather hostile environment in which information was exchanged only piecewise with the team members reciprocating each other. This rather hostile start was perceived as personally annoying but could eventually be leveled out over time and with increasing investments in the partnership, with each partner coming to respect and appreciate the distinct capabilities of the other.

Taken together, three central moderating variables have been identified. Some interviewees underscored a **shared scientific approach** to R&D as well as a high degree of **projectification** of R&D that helped to identify with the partner and circumvent inter-organisational friction. Other interviewees reported that they **anticipated** organisational differences as they were themselves **experienced** in either academic science or large firms. If problems did occur, interviewees reported a lack of **goal congruency**, **incongruent incentives** and **structural incompatibilities**, which led to **disagreements**, **irritations**, **dissatisfaction** and **delays** or **intransparency**, which at times led to motivational backlashes in the form of resistance or buck-passing.

These results partially support the suggested negative effects of organisational distance in respect to goal achievement, the efficiency of the project and the satisfaction of those involved. However, there was no homogeneous pattern across the cases, with the experiences being highly individual and partner-specific. This insight also explains the high dispersion of the data and the low levels of statistical significance in the regression results. Moreover, the reported effects were rather structural than communicative. They related to motivational issues, not the ability of the scientists to share knowledge. The organisational differences often resulted in an unsettling, arduous process that explains the high negative result in regard to personal outcomes. Thus, organisational incompatibilities by and large did not directly affect knowledge sharing between the partners. In addition, they were sometimes not the source of conflict, but only came to the fore in the case of escalation or conflict.

Strategic Distance

The dimension of strategic distance was included to capture any effects that might result from situations of current or future, direct or indirect rivalry between the partners and the partners' partners. In the literature, this is often referred to as a situation of 'co-opetition' (section 4.4.4). In respect to the expected effects, two contrary arguments have been discussed. On the one hand, the effect of strategic proximity on goal achievement has been expected to be positive, as the partners are motivated to derive maximum benefit from the co-operation project. This is mainly driven by a positive effect of strategic proximity on the level of inventiveness of the project and the joint realisation of strategic goals (hypothesis 4a). On the other hand, the effect of strategic proximity on the realisation of the project's goals has been suggested to be negative; this has been suggested to be particularly pronounced in regard to the project's inventive and strategic outcomes, its efficiency (operational outcomes), the personal satisfaction and learning effects (personal outcomes), as well as the establishment of a long-term, trusting relationship between the partners and access to other partners (relational outcomes) (hypotheses 4b).

Turning to the regression results in table 8.21, two results attract attention: strategic distance exerts a significantly negative impact on goal achievement ($p<.10$) as well as the achievement of strategic outcomes ($p<.01$). These findings support hypothesis 4a, suggesting that the 'inventive steam' of a co-operation project is higher when the partners are strategically close, but conversely is lower when the partners are strategically distant. It seems that the partners do not resort to overly protective behaviour in regard to knowledge sharing. The second finding in regard to the strategic outcome dimension can be explained in that strategic goals – such as accessing markets, gaining market dominance or establishing international (de facto) standards – are more likely to be realised with partners pursuing comparable strategic aspirations. However, from the quantitative results, no immediate positive effect of strategic proximity on the inventive outcomes could be made out. Although the sign of the coefficient is negative, it is not statistically significant.

Although it is difficult to establish a positive effect of strategic proximity from qualitative data, no overarching negative effect could be identified from the analysis.

While a direct (current or prospective) competitive threat was mostly not perceived by the interviewees, indirect links to competitors through the focal partner were mostly acknowledged as possible, but of no great concern (see table 8.14).

Three **moderating variables** have been identified from the qualitative data: a reliance on the professional ethos (loyalty) of the partner; the high specificity of knowledge; and the high dynamics of biotechnology knowledge creation (short half-life of knowledge).

First, in regard to the potential risk emanating from indirect knowledge spillovers to third parties, most interviewees relied on the loyalty of their partner, as the following quote illustrates:

> *'Loyalty is a very important factor, [as you] can't bind him [the partner] exclusively. ... This is a feeling, not a factor you can measure.' (IP33)*

As the firms saw no possibility of ruling out this threat, they perceived this largely as *'a matter of trust' (IP19)*. Others referred to the partner's professionalism, which would not allow him to reveal any information to third parties. Moreover, one interviewee expressed that *'he [the partner] cannot afford this [to spread the knowledge]' (IP10)*, as he would lose a financial source, also for future co-operation, as well as his standing.

Competitive threats were also seen as leveled out by the high dynamics of biotechnology knowledge and a short half-life of knowledge. Thus, the pace of knowledge creation and its obsolescence was perceived as being so fast in many areas of modern biotechnology that competitive considerations generally played less of a role:

> *'This [competitive considerations] does not play a role. ... The environment is so dynamic that I need the success today. I need not think about what might be in three years time.' (IP7)*

Others refer to the high specificity of their technology or knowledge base. It is different designs or approaches that compete rather than firms in regard to similar approaches. Hence, knowledge drain was not directly feared. By contrast, two firms that perceived themselves to be in a co-opetitive relationship reported that they were primarily driven by the quest to jointly advance a certain scientific or technological field. With many of these technologies being in nascent stages, rivals were perceived as strategic partners to jointly advance the spread of the technology, increase the acceptance and set (de facto) standards in the field. Besides, the markets were perceived as huge and each company would fill a niche.

Some weaker **effects** of strategic proximity could be identified: in cases where competitive risks, primarily indirectly, were acknowledged, the firms responded primarily by three strategies: exit, (i.e., avoidance of the partnership); loyalty, (i.e., trust in the partner's loyalty and professionalism; see above); or voice, which implies a policy of demarcation, either contractually or implicit in everyday work. Thus, some firms aimed to avoid constellations of direct rivalry within co-operation projects, perceiving them as generally *'more difficult' (IP12)*. One interviewee claimed that

> *'one needs to dispel this in advance ... when choosing a partner. If the project is to be run successfully, everything that is necessary needs to be exchanged. Otherwise the whole project is at risk.' (IP25)*

In case indirect or direct threats from competition were perceived, firms either resorted to loyalty strategies or reacted by drawing *'a line' (IP10)* on what to share and what not to share with the partner and by contractually hedging against unintended knowledge drain. This was reported by one firm in a co-operation project with a university partner:

> *'We collaborate only with one specific work group; however, when contracting, the whole university is your contractual partner ... and one never knows what partnerships such a large university enters and what it then does in detail, for example when they have access to a patent. It might happen that, for example three work groups farther, a co-operation is about to be started where the patent might be relevant. Hence, it [considerations of indirect knowledge spillover] has an influence, it is important to not concede the academic partner too much influence. ... This comes then to contracting.' (IP11)*

This is corroborated by another interviewee:

> *'Beyond the project we were of course rivals. [Did this have an impact on the project?] Sure. Well, not necessarily in regard to the project, but certain things that we could do and they couldn't do, which were also within our work package, we didn't tell them. This is clear. Only insofar as it was necessary for the project.' (IP20)*

According to the interviewees, this 'line' that was drawn primarily concerned the broader strategic outlook of the firm, whereas all information necessary for the focal project was exchanged. As long as all necessary data in regard to the project was revealed, this selective information policy was not perceived as a disadvantage for the realisation of the project's goals. By contrast, a policy of consciously withholding information that was needed to advance the project was perceived as *'fatal' (IP15)* for the joint project.

However, another interviewee admitted that openness toward the partner necessitated time and increasing levels of trust:

> *'Yes, I believe, to be honest, this [a conscious knowledge policy] was somewhat the case. More at the beginning than during the project. This is due to the development of the collaboration ... and trust. In the early stages, one was likely to consider, okay, we communicate what is necessary, but not more. Later, when we know that he [the partner] does nothing he isn't allowed to, one has greater trust and acts more openly.' (IP27)*

Taken together, key moderating variables that were repeatedly expressed in the interviews included a reliance on the partner's **loyalty** or **professionalism**. Furthermore, a high **specificity of knowledge** coupled with the **high dynamics** of the field of biotechnology led to lower perceptions of competitive risks. If competitive threats were acknowledged, three protection strategies were reported by the interviews: avoidance, loyalty and voice, implying that the firms clearly demarcated the area of co-operation and thus the knowledge to be shared with the partner, usually with contractual safeguards to prevent knowledge diffusion to third parties. Thus, some interviewees adopted a more **conscious** and **focused** approach to **knowledge sharing**, particularly at the start, with increasing levels of openness and higher levels of trust developing over time. Therefore, while the positive effect of strategic proximity as revealed in the regression model could not be directly inferred from the qualitative data, the antithesis of an overly protective behaviour could not be identified either.

Technological Distance

Building on the insight from innovation theory that invention often occurs through a recombination of distinct bodies of knowledge and assuming that proximate bodies of knowledge yield little novelty, it was suggested that higher levels of technological distance are conducive for novelty generation. Coupled with insights from learning theory, however, it was suggested that firms - and the people involved - have difficulties in combining, i.e., sharing as well as assimilating and making use of, knowledge that exceeds their cognitive capacities. In this case, communication was suggested to be not only inefficient, but could also lead to frustration and disappointment for the individuals involved. In addition, the existence of potentially exclusive mechanisms of epistemic communities and fears of losing one's expert status have been discussed, which might lead to motivational drawbacks to sharing knowledge with outsiders (section 4.4.5). Together, these suggestions pointed to an inverted U-shaped relationship between technological distance and the realisation of the project's goals. Similar results are expected for the inventive and personal outcomes, but not for the operational outcomes, which are assumed to be negatively affected by increasing levels of technological distance (hypothesis 5a). Furthermore, it was suggested that in regard to the partner's knowledge base composition, these effects might be particularly pronounced with differences in the basic bodies of knowledge (hypothesis 5b).

These suggestions are strongly supported by the results of the regression analysis, which confirm an inverted U-shaped relationship of technological distance across all outcome dimensions (table 8.21). This is displayed in highly significant positive linear as well as quadratic coefficients of technological distance at significance levels between 0.1 and 5%. This inverted U-shaped relationship is strongest in regard to the realisation of inventive outcomes, followed by personal, strategic and relational outcomes, and the global measure of goal achievement. It displays the lowest levels for the achievement of operational outcomes. That is, while technological distance, up to a maximum level after which its contribution turns negative, is conducive to invention as well as the realisation of strategic goals, the accession of new ties, and personal satisfaction with the co-operation project, its effects on the efficiency of the project in regard to compliance with timelines and budgets are less pronounced.

Thus, the inverted U-shaped relationship between technological distance and goal achievement as well as different outcome categories (primarily inventive and personal) has clearly been corroborated by the data, confirming hypothesis 5a.

This result is also backed by the qualitative data. First of all, from the qualitative data it became evident that the desired complementarities largely concerned specific or emerging knowledge at the forefront of the firm's own or related knowledge fields. Thus, in most of the cases, the co-operation partners moved within the broad area of biotechnology knowledge and expertise, although each partner had pursued a distinct trajectory in regard to his specialised body of expertise (see table 8.14).

As has been predicted, a strong **moderating effect** emanates from the existence of transversal knowledge, mostly in the form of shared disciplinary or basic knowledge, or knowledge brokers, understood as individuals who are either well versed and experienced in both knowledge bases or else gain enough insight to function as a translator or moderator. Thus, one interviewee recommends that the partners *'should be scientifically complementary and at the same time an overlap should exist in certain areas' (IP36).*

Most interviewees acknowledged the supportive impact of an overlap in the basic knowledge bases of the partners in order to communicate and share knowledge. The positive effect of an overlap in basic understanding is well illustrated in the following quote:

> *'the molecular biological spectrum [of the partners] is similar. [The difference is] that we have strongly concentrated on protein engineering itself, while for them this is the tool they need to advance a certain field. ... Both are trained in molecular biology. This is comparable. ... This is why we understood each other well. We had no problem to communicate, because both are molecular biologists and both understand the methods and how to answer the problem.' (IP15)*

The facilitative role of some redundancy in knowledge was acknowledged by most interviewees. This is also well illustrated in a case co-operation project that centered on the joint development of a new bioinformatics application between a firm and a university group:

> *'We have people trained in informatics and biology. The partner has primarily biologists. ... It is our bioinformaticians who understand both worlds and who communicate with the partner.' (IP10)*

One interviewee stressed that this overlap can also be warranted through specific individuals who adopt the role of a translator between the partners. These 'knowledge brokers' were either trained in the knowledge of the partner, had ample experience in the partner's field of expertise or gain enough insight into the knowledge and operations of the partners, which allows them to comprehend the basics of the partner's knowledge and techniques. In the words of one interviewee:

> *'It is important that there is somebody who can mediate between the disciplines. ... Simply someone who has or gains enough insight and who can, in the case of misunderstandings or lack of understanding, intervene and explicate; someone who brings the people on one level again.' (IP22)*

Thus, a common denominator in knowledge or someone who adopts the role of a translator was perceived as highly supportive in several of the co-operation projects.

However, particularly in small firms that often specialise in a very narrow field and employ fewer people in terms of numbers and disciplines or specialties, there is less chance for the existence of an area of overlap. It has been observed that knowledge ties are more strongly bound to individual people and their personal experience, or otherwise not present.

Turning to the **effects**, it is first of all pertinent that the co-operation projects served to leverage complementary knowledge and skills from the partners (see section 8.3.1). Hence, some degree of technological distance was desired and deliberately sought by the partners. In the words of the interviewees, these were the *'complementarities sought' (IP27)* or *'they knew what we didn't know' (IP5)*. Interestingly, one interviewee refined this notion of complementarity in the following way:

> *'At the start of the project we* assumed *we* might have *developed a complementary technology' (IP7, underscored by the interviewee)*,

the proof of which was still to be made during the co-operation project. This relativisation also shows the large degree of uncertainty that was sometimes noted by the interviewees, particularly in the early research stages.

With greater levels of technological (or knowledge) distance and in the absence of a boundary spanner who translates and mediates, larger problems in communication between the partners have been revealed. From one German–British firm–university co-operation project, the interviewee explained that he experienced misunderstandings or irritations as:

> *'They [the methods applied by the partners] differ. The partner uses mass spectrometry, protein analysis and [the focal firm] is traditionally a firm that concentrates on DNA. ... Hence, in the beginning, there were misunderstandings or simply different perspectives. ... At some point we realised the need for communication and practised more communication. This is the lesson learned: one should do it [communicate] earlier and more intensely.' (IP11)*

Although both partners were active in the broad area of modern biotechnology, their specialised skills were too different to presuppose initial understanding between the partners. However, the assumptions of the firms in regard to their own ease of understanding the knowledge of the partner and, vice versa, the level of comprehension expected from the partner, were at times incorrect. In other co-operation projects it has been observed that the need for communication was realised at a rather late stage of the co-operation project after frustration had already set in. For example, from one co-operation project with a Canadian academic partner, the interviewee reported that:

> *'we sometimes had the feeling of not being properly informed [by the partner] concerning the scientific background, because, at that time, we were not yet well versed in it [the technique of the partner]. Maybe we should have asked more. On the other hand, they presupposed that we knew everything already. They didn't attach high importance to involving us. For example, in regard to different*

> *methods to stain the cells ... We also thought again and again that we had understood what it was about and then realised that this was actually not the case. Then we had to ask the partner again and he started to get irritated: "Are they too stupid to understand this?" And we thought "Why doesn't he tell us everything?" ... In the end, after much back and forth and questioning on our part, it has been solved for mutual satisfaction. But this communication process on the content of the research, this was difficult.' (IP43)*

This quote well illustrates the underestimation of competence problems where information needs and information offers were not aligned, based on incorrect assumptions. This kind of situation sometimes occurred in constellations where the partners perceived each other as relatively close in knowledge, due to a common industrial or technological background, but turned out to be too distant in their specialised knowledge bases to fully comprehend the partner's domain knowledge. In one cooperation project, which was characterised by high levels of technological distance, communication problems occurred

> *'because of a lack of knowledge on the partner's side. We know our technology in detail, but our partner only applied it. He struggled to formulate his problem. Then one of our employees needed to go there again and inspect the problem on-site. ... Thus, you should not overestimate what your partner already knows, but also not underestimate what he does understand.' (IP37)*

In this case, no shared language existed between the partners in order to communicate the problems. As the interviewee said, the partner 'struggled' to express his problem. Consequently, higher investments on the part of the focal firm were needed to travel to the partner in order to inspect the problem on site, to demonstrate and explain the mechanisms, before the project could proceed. These higher investments eventually led to lower motivation among the team members. The interviewee observed that the team members over time became weary of traveling, expressing their unwillingness ironically as *'win a ticket' (IP37)* for a journey to the US.

Likewise, some interviewees felt that partners who were not experienced in a certain knowledge domain displayed a degree of *'naivety' (IP30)* in regard to the complexity and limits of the other's knowledge and capabilities. For example, there was a lack of understanding for the time certain activities claimed as well as the limits imposed by the state of the technology, which led to impatience and frustrations on both sides. One interviewee concludes that

> *'One needs to learn in order to understand the limits and problems of the partner ... Within this kind of collaboration there are always aspects [on the part of the partner] one has to comprehend, in order to bring the whole entity to success.' (IP7)*

This need for learning was also expressed by another interviewee:

> *'I believe this is a reason for the failure of many co-operation projects ... that there is a deviating understanding for the expertise and tasks of the other. Communication is an important point, ... but there is also much learning by doing. You have to accept that.' (IP43)*

Another area of conflict that was experienced in two co-operation projects was the non-acceptance of a different approach, accompanied by a lack of esteem for the other or a tendency to accuse the other discipline if things went wrong. Hence, one interviewee provided a more subtle explanation for potential difficulties when different disciplines come together that are on the one hand distinct, yet on the other hand close enough to know the weaknesses of the other. From his experience, he observed that

> *'problems are generally ... ascribed to the other field. This renders the whole thing [inter-disciplinary co-operation] very subtle and nasty. The biologist knows the weakness of the chemist and ascribes the problems to him, because he understands [his problems].' (IP7)*

This quote demonstrates the fact that social groups are created on the basis of a team member's disciplinary belonging. In this situation, buck-passing occurred that inhibited joint problem-solving and the team's internal cohesion.

However, one interviewee held a rival view on the communication behaviour in a team when large technological or disciplinary distances exist. He assumes that

> *'the more different the disciplines, ... the more patiently one generally deals with the partner, in case one is determined to proceed together at all.' (IP10)*

He suggests that the more salient the differences, the more the team members are aware of them and adjust their communication behaviour accordingly. A communication impedance was observed where the amount of information was reduced when the partner was expected to have a similar knowledge background. Thus, when a threshold level of distance is surmounted, the need to externalise a greater share of one's knowledge becomes overt. The partners become aware of eventual communication problems and deliberately invest higher efforts in knowledge sharing. However, this does not automatically imply higher successes in knowledge sharing with increasing levels of technological distance.

While the discussion so far related to communication impedances and motivational effects of technological distance between the partners, the fusion of technically distant bodies of knowledge itself bears a greater risk of (technical) failure. That is, in some constellations where firms aimed to have an early stake in an emerging field or tried to fuse distant knowledge bases, the co-operation project did not contribute the expected results as it was previously not clear or foreseeable in what way this particular *'non-standard' (IP19)* approach could contribute to solving existing problems or to generating new applications. Hence, the more distant the combined bodies of expertise, the more the partners struggled to anticipate the feasibility and potential value of the project. While bearing the potential for more radical, groundbreaking novelty, this strategy also bears the risk that the initial ideas do not materialise and the project does not live up to the initial expectations.

Taken together, while complementary knowledge and skills are sought within the co-operation, most interviewees stressed the existence as well as the importance of an overlap or **redundancy** in knowledge base as a central moderating variable. This redundancy can be based on shared methods and techniques, a shared formal training in the more basic bodies of knowledge, such as biology, medicine or informatics, or past experience in the other's field. At minimum, a translator or **knowledge broker** between the different knowledge bases of the partners is perceived as helpful. Thus, a positive effect is derived from the combined **complementary** knowledge, which is accompanied by **synergies** or **learning** effects. However, the challenges and effects of differences in knowledge and expertise between the partners are often initially underrated by the partners. They are often very subtle and even found in closely delineated scientific fields. Most of the interviewees who experienced differences in knowledge and techniques reported that they were faced with problems during the co-operation and reacted with more communication. Among these problems were a **lack of codes** for communication and problem description, **incomplete assumptions** on the information needs of the other, a degree of **naivety** in regard to the knowledge as well as challenges of the partner, leading to higher incidences of **misunderstandings** and **impatience**. Motivational boundaries such as a **lack of respect**, **resistance** or **buck-passing** have also been mentioned, though only occasionally. Hence, technological distance is important in co-operation and has a very positive effect on goal achievement, but it can also pose incommensurable friction in the process of knowledge sharing and particularly learning, when the differences become too large or are only realised and responded to after some delay.

Therefore, the qualitative insights underscore the findings from the quantitative analysis, providing insights into potential friction when the ability and motivation of the partners to share knowledge come to their limits. The qualitative description has also demonstrated that the technological dimension of distance is most directly related to knowledge-sharing ability and closest related to the primary value-generating task. Both have been assumed to exert a strong effect on the outcomes of the co-operation. Even more, the previous discussion has corroborated the impact of shared basic knowledge bases between the partners (hypothesis 5b). However, the firms are highly specialised in niches that, even given a shared basic body of knowledge, does not necessarily imply a thorough understanding of the knowledge, skills and limits of the partner.

Relational Distance

Theoretically, the dimension relational distance draws on insights from Social Network Perspectives (section 2.4). It ties in on a contemporary discussion in the field on the benefits and liabilities of close versus distant ties in inter-organisational co-operation. On the one hand, the inventive potential of repeated ties might be reduced in that the knowledge of both partners is well-known and new combinations of knowledge and skills are less likely to occur. Thus, new ties bring about more novelty. On the other hand, repeated relationships have accumulated social capital, which is manifest in the structural and cognitive convergence of the partners as well as other relational advantages, such as trust, a higher motivation and commitment of the partners. Opposing both effects suggests an optimal intermediate level of relational distance that argues in favour of an inverted U-shaped relationship between relational distance and the achievement of a project's goals as well as inventive and strategic outcomes of the project. The negative effect is particularly attributed to lower levels of efficiency and personal satisfaction due to increased investments to align knowledge bases, codes and routines (hypothesis 6).

In this dimension, the results of the regression analysis in table 8.21 display a less clear and coherent pattern across the outcome dimensions. There is only one statistically significant relationship, which posits an inverted U-shaped relationship between relational distance and the operational outcome dimension in both the linear and the quadratic term ($p<.10$). This finding suggests the need for higher initial investments when a new relationship is incurred. In addition, very tight previous relationships display low levels of efficiency. This lower efficiency might be due to less formal and strict planning and co-ordination over time. However, the coefficients in the other outcome dimensions allow no statistic interpretation. Thus, hypothesis 6 is only partially confirmed with regard to the operational outcome; the remaining suggestions could not be established and thus need to be rejected.

For the interpretation of this result it is important to reconsider the distribution of the original data (see table 8.14). It is known that the initial levels of relational proximity in the sample co-operation projects were generally low. Most of these projects were initiated from scratch. In those instances where the partners were acquainted before, the ties built on – in descending order in regard to the indicated tie strength – customer–seller relationships, joint committee activity or previous acquaintance from conferences or fairs. None of these partnerships built on the experience of previous joint co-operation projects in R&D. Integrating the theoretical distinction of structural, cognitive and relational social capital, it can be concluded that only relational capital, in the form of trust, mutual obligations and expectations of shared social norms, can exist through this type of relationship, while the other dimensions of social capital demand a shared history of previous interaction in a similar or comparable domain.

Thus, discussing the topic of relational proximity with the interviewees, most of them addressed the role of trust between the partners. In the words of one interviewee,

> *'this [biotechnology] is a business of trust' (IP2).*

In the absence of previous direct experience with the partner, key **moderating variables** were: first, the partner's reputation, both in regard to his competencies as well as his behaviour; and second, a personal – partly rational, partly affective – judgment based on a first assessment of competencies and initial sympathy.

Centrally, the reputation of the partner played a role, which substituted for direct previous acquaintance. Thus, reputation can be seen as a distinct network resource that indicates the competence and reliability of a potential partner. However, a conflict was noted as the most novel knowledge is often contributed by less well-known or new players.

In a number of cases, the interviewees reported that the co-operation project was initiated on the back of an email query or a telephone call. Usually, a preliminary period of exchanges backed by the evaluation of secondary information sources followed in order to assess the quality and honesty of the partner. Hence, trust is often *'built up in preparation and during collaboration' (IP9)*. Moreover, in this business that displays a high need to frequently integrate external knowledge and skills and where new players often emerge without a track record of previous relationships and successes, some interviewees reported relying on their instinct and their accumulated experience to judge other people and ideas. A feeling of being *'on the same wavelength' (IP27)* was frequently reported by the interviewees as a decisive factor in entering a co-operation project. Besides, most firms built on the expectation of non-opportunistic behaviour, as long as it was not violated by the partner. This behaviour lends support to Nooteboom's suggestion of 'trust as a default' (Nooteboom, 2004a, p. 510). This behaviour does not imply that the firms are blind to relational risks, but depart from the assumed trustworthiness of the partner.

While it is difficult to identify the **effects** of relational distance from the qualitative data, the presentation draws primarily on the identified effects of relational proximity as reported by the interviewees. Thus, asked whether the existence of a previous customer–seller relationship affected the focal co-operation project in R&D, one interviewee responded:

> *'In any case, yes. On the one hand, trust was certainly only given because we had worked together before as customer and supplier.*

Through this, the partner had seen that we (a) work professionally, and (b) we won't pull a fast one on him; that we are fair and have the competence to realise it [the goals]. I believe the trust that was needed for them to pass their invention into our hands was the result of this slowly built relationship.' (IP11)

The meaning of prior relationships for trust is corroborated by another interviewee who was engaged in a development co-operation project with a Korean university:

'This [prior relational proximity] is always important, particularly with such different cultures. We knew each other from joint committee activities. We also had a co-operation at the university level some time ago.' (IP20)

This quote makes an interesting additional point, linking relational proximity with institutional distance. In this case, a history of shared relationships with a particular partner from an institutionally distant country was perceived as an important precedent to the current relationship and attained level of trust among the partners. Particularly as the relational risks in regard to sharing knowledge with the partner tends to be high in collaborative R&D with institutionally distant partners, this initial level of trust was perceived as a prerequisite for inter-organisational co-operation by the interviewees.

Conversely, a number of interviewees reported that, in the absence of previous relationships, they were initially cautious about fully revealing their knowledge before a certain level of trust in the partner, his behaviour and capabilities had been established. This lead-time in the generation of trust is illustrated in the following quote:

'This [the co-operation project] has now been running for two years. Only now it gets up to full speed. Meanwhile, we come to the point where our technical colleagues [from the partner firm] are looking forward to our discussions. One has the feeling that we convinced them that we are honest and reasonable, tell the truth, and give our best. And the best: we have the feeling that we bring novelty to them; a new way of seeing and doing things.' (IP30)

Only with growing levels of relational proximity could the full potential of the combination of the resources be realised. In this sense, the earlier a requisite level of relational proximity is established, the earlier the project can run at 'full speed'.

One interviewee reported a contrasting experience. In his case, a co-operation project was based on a long-term personal relationship between two executive managers who initiated the co-operation project, but were not personally involved in the operation of the project. The interviewee experienced this as a burden, as

> *'from my perspective, this [the prior informal relationship on the management level] renders it [the collaboration] in parts more taxing, which happens in my experience when a partnership strongly builds on prior personal relationships. ... There are collaborations that are really simple. Objective, business-driven, clear contractual arrangements. ... From that moment when strong personal relationships stand behind the matter, it inevitably becomes more tricky and more emotional at times. Some things are softer, one avoids formalising everything. Yet, the clearer and more explicitly the goals are fixed, the less room for interpretation is left later. With personal relationships, one just doesn't want to hurt each other.' (IP25)*

This quote illustrates a potential flip side of relational proximity. The focal interviewee was (personally) less satisfied with the course and outcome of the co-operation, being personally obliged to continue in the best manner possible and to avoid conflict, even when conflict was perceived as necessary.

It was mentioned before that most of the interviewees associated relational proximity with trust. Only one interviewee related relational proximity to familiarity with the procedures of the partner and the establishment of inter-organisational routines. The interviewee saw a key benefit of repeated collaboration with a specific university in the familiarity with the specific procedures and operations of the partner, because *'if you enter into collaboration with a university for the first time, you come across many obstacles' (IP5).* According to the interviewee, experience with a specific organisation helps to overcome these barriers.

Most of the interviewees addressed the importance of trust as a key variable. However, due to problems in evaluation and the pace of the industry, the competence and trustworthiness of the partner was often based on his **reputation**, or the decision-maker's instinct, **personal judgment** and **affection** (similar wavelength) turned out as central moderating variables. In most cases, **trust** was the **default**, as long as it was not challenged by the partner. However, some interviewees judged prior direct experience of the partner as an important asset that gave them access to the partner's knowledge and skills together with a higher level of openness with the partner. In other cases, where the level of acquaintance was initially low, a **hesitant** knowledge sharing with a **gradual opening** over **time** were reported. While trust was reported as central, other benefits from relational proximity, such as a convergence in organisational styles, the establishment of inter-organisational routines, or a cognitive or technological convergence, could not be observed, which is presumably a specific inherent in the database that is largely composed of newly leveraged relationships. However, some liabilities of too-close personal relationships have been reported where the personal relationship dominated economic calculus. In this case, energy was diverted to keep the partner content and to avoid conflict, which was perceived as a burden on the relationship.

The qualitative data primarily revealed the time aspect to establish trust and thus supported the suggested negative effect of relational distance on the operational outcomes (see hypothesis 6). However, generally low levels of prior relational proximity did not allow exploring the remaining suggestions more thoroughly.

Relative Weight of the Dimensions

It has further been suggested that the more directly a dimension of distance is linked to knowledge and cognition, i.e., the cognitive variety induced into the project as well as the cognitive abilities of the partners to share their knowledge – and thus the closer it is to the primary value-generating task – the higher its (positive as well as negative) impact on the outcomes of an inter-organisational co-operation project (hypothesis 7). In line with the theoretical discussion offered in sections 4.4.1 to 4.4.6, stronger effects have been expected for the technological, moderate effects for the institutional, and weaker effects for the organisational dimension.

From the regression results, this hypothesis is by and large corroborated. The most significant effects throughout the different outcome categories have been observed for the dimension of technological distance, followed by institutional distance. Both dimensions, technological and institutional distance, follow an inverted U-shaped relationship across (most of) the outcome dimensions. They contribute novelty or alternative views; however, they also aggravate knowledge sharing between the partners with increasing levels of distance.

The qualitative analysis has likewise confirmed that these two dimensions directly affect the ability of the partners to share their knowledge; be it through the lack of a shared language (culturally, technically) or a basic understanding of scientific and technological principles of each other's knowledge and skills. Yet, comparing the relative influence of technological and institutional distance, it became obvious that it is rather technological diversity that leads to new combinations or complementary synergies than institutional, particularly cultural, diversity. Furthermore, turning to the downside of greater degrees of distance, technological distance is even harder to tackle as it leads to fundamental disparities in understanding, while institutional distance is primarily accompanied by fragmentary or improper information transfer due to different proficiencies in the use of a shared language. This discussion further suggests that with high levels of distance in both dimensions simultaneously, knowledge sharing between the partners easily comes to its limits. On the other hand, provided a similar knowledge stock exists, the partners can make up for gaps in information from high levels of institutional distance and a correct interpretation is more likely to be made.

However, against initial expectations, organisational distance has only a minor, mostly non-significant, impact on the degree of goal achievement and other outcome variables. It is rather associated with incongruent incentives, structures and work organisations that inhibit frictionless co-ordination, while cognitive limitations affecting the ability to share knowledge could not be related to organisational distance. Similarly, all other dimensions (strategic, relational distance) are rather related to motivational factors to share knowledge and mostly do not exhibit coherent and significant effects. Thus, the suggested relative weight among the different dimensions is largely corroborated, particularly in regard to the technological and the institutional dimensions.

Interaction Effects

So far, single effects and relative weights of the different dimensions of distance have been discussed. The following analysis now turns to the proposed interaction effects between different dimensions. In section 4.5, it has been outlined that the deconstruction of different dimensions of distance and their separate investigation is needed to single out different effects that can be attributed to any one dimension in order to gain in-depth insights into key relationships and mechanisms. Nonetheless, interaction effects between different dimensions have been suggested. Based on the theoretical discussion, it has been suggested that geographic and relational distance exert a rather indirect influence on the course and outcomes of an inter-organisational co-operation project (hypothesis 8a). This implies that they will exert their full influence only in combination with other dimensions of distance. It has further been suggested that this indirect effect is particularly pronounced for those variables that are directly related to knowledge and cognition, i.e., the ability of the partners to share their knowledge; again, in descending order, technological, institutional and organisational distance (hypothesis 8b).[32]

Technically, interaction effects are calculated through the integration of a product term into the regression model, which includes the product of the variables of interest (Allison, 1977).[33] Thus, in order to investigate the hypothesised indirect nature of the two dimensions of geographic and relational distance, interaction terms between the respective dimension and the other dimensions of distance have been integrated into the original regression model. As dependent variable, the degree of goal achievement has been chosen as a global measure for the success of the project.

The results for **geographic distance** are presented in table 8.24. First of all, the inclusion of the interaction terms into the regression model improves their explanatory power compared to the original model in table 8.21 with a higher level for R^2_{pseudo}, particularly for those interaction models that reveal significant interaction coefficients (models II and IV). Likewise, the measure Prob > Chi^2 improves slightly in these models. Across the models, the control coefficients remain remarkably constant in sign and significance, and correspond largely to the ones reported in the original model.[34]

Reconsidering the result of the original regression model in table 8.21, it turned out that the level of goal achievement was not affected by geographic distance. The results of the interaction models now show that the combination of geographic

[32] Note that it has been revealed meanwhile that organisational distance is less related to knowledge sharing and cognition.

[33] Before building the interaction terms, the respective variables were z-standardised as recommended by Kohler and Kreuter (2008).

[34] Thus, the control variables are not discussed again in this paragraph.

Table 8.24: Interaction Effects: The Indirect Nature of Geographic Distance

	I	II	III	IV	V
Geographic distance	-0.16	0.62	0.10	0.64	0.35
Institutional distance	1.95*	1.76†	1.81†	1.62†	1.91*
(Institutional distance)^2	-0.42*	-0.38†	-0.39†	-0.35†	-0.42*
Organisational distance	-0.02	-0.04	-0.04	-0.00	-0.01
Strategic distance	-0.22†	-0.16	-0.21†	-0.20†	-0.23†
Technological distance	2.08*	2.20**	2.00**	2.32**	2.09**
(Technological distance)^2	-0.49**	-0.52***	-0.48***	-0.53**	-0.49***
Relational distance	0.44	0.05	0.05	0.54	0.41
(Relational distance)^2	-0.03	0.03	0.02	-0.04	-0.03
(Geographic distance) · (Institutional distance)	0.03				
(Geographic distance) · (Organisational distance)		-0.22†			
(Geographic distance) · (Strategic distance)			-0.08		
(Geographic distance) · (Technological distance)				-0.21†	
(Geographic distance) · (Relational distance)					-0.10
Firm size	0.00†	0.00†	0.00†	0.00*	0.00*
Firm age	0.01	0.02	0.01	0.01	0.02
R&D intensity	0.10	0.08	0.07	0.13	0.10
R&D breadth	-0.12	-0.03	-0.13	-0.02	-0.11
Network Centrality	-0.13	-0.24	-0.11	-0.28	-0.14
Duration	-0.24	-0.21	-0.21	-0.26	-0.24
Inv. stage	0.54†	0.29	0.55†	0.41	0.54†
Learn. rationale	0.18	0.40	0.20	0.10	0.19
Constant	-0.14	0.50	0.50	0.17	-0.10
Sigma constant	0.50***	0.48***	0.50***	0.48***	0.50***
No. of cases	39	39	39	39	39
log-likelihood	-26.28	-24.79	-26.13	-25.13	-26.20
Chi^2	43.70	46.68	43.99	45.99	43.86
Prob > Chi^2	0.0006	0.0002	0.0006	0.0003	0.0006
R^2 pseudo	0.45	0.48	0.46	0.48	0.46

† $p<.10$, * $p<.05$, ** $p<.01$, *** $p<.001$

distance with high levels of distance in other dimensions eventually displays a significant negative effect. This applies when geographic distance is combined with organisational (model II) and technological distance (model IV), where the interaction coefficients become significant ($p<.10$).

Considering first model II, the insights from the original model can be refined: while both single effects of increasing levels of geographic and organisational distance are not significant, their joint occurrence has a negative impact on goal achievement, which explains some of the variance in the original data. Thus, when the partner is located at considerable geographic distance, the positive effect of looking for a good, or the best, partner abroad can turn into a liability when the partner is also characterised by marked organisational differences. Conversely, firms cope less well with differences in mindsets, structures, routines and organisational culture, the farther away the partner is located in geographical terms. They have fewer possibilities to become acquainted and familiar with the partner's style and operations.

These suggestions are also supported by the qualitative data. A number of interviewees reported that they felt they had less insight, control and influence on the operations of the partner with increasing levels of geographic and organisational distance combined. Furthermore, delays during the course of the co-operation project due to diverging priorities attached to a project and different time schedules of the partners primarily occurred when organisational and geographic distance co-occurred. Remember one interviewee claiming: *'sometimes we couldn't understand why something was delayed. We didn't figure out everything. Then it does play a role – I mean geography and culture' (IP22).* In these cases, the firms had problems understanding what was happening on the other side. The projects were more likely to take a back seat on the partner's agenda and the partner had the possibility to *'entrench[...] himself behind an email' (IP12).* Another interviewee reported that they had the feeling that projects were prioritised according to the geographic reach of the partner, where nearby partners are generally better off than those located at geographic distance. Thus, with email and telephone as prime media for communication, some interviewees reported high degrees of intransparency of the partner's actions and experienced problems in the enforcement of the co-operation project. Firms at times struggled to get their project through when they didn't have the possibility for frequent face-to-face contact and to *'step on the other's feet' (IP12)* if necessary. These difficulties occurred primarily at high levels of organisational distance where the actions and decisions of the partner could not be predicted or understood from outside.

The second significant interaction effect that was revealed in the regression model concerns the interplay between geographic and technological distance (model IV). The statistically significant negative interaction coefficient implies that the integration of technologically distant partners becomes more difficult when high levels of technological distance and high levels of geographic distance co-occur. Thus, the partners eventually face a liability in exploiting the full potential of higher levels of technological distance when they have to bridge considerable geographic distance. Conversely, geographic proximity can support the combination of more distant bodies of knowledge between the partners.

It has been confirmed in the qualitative analysis that the partners tend to see each other less frequently when they are located apart from each other and communication is primarily affected via electronic means. Thus, externalisation in the form of articulation and codification of knowledge become important. This transformatory step does not necessarily pose a problem when the partners share a requisite amount of knowledge and codes. This is well documented in the following quote from a small firm collaborating with a US partner, who was perceived as highly similar in regard to his field of expertise in proteomics:

> *'You didn't have to spend much time to discuss and explain. The understanding was there. In most of the cases, the emails that were exchanged were not too long, because the content was clear.' (IP15)*

In this case, a tie between two people from the same narrowly delineated scientific field was spanned and geographic distance with an accompanied shift to electronic means for communication was not perceived as a hindrance for effective and efficient communication between the sub-teams.

However, when the partners didn't share a basic scientific or technical understanding, both lower frequency and lower richness in communication rendered inter-organisational knowledge sharing and the combination of distinct bodies of knowledge more complex. This is well illustrated in two cases that were cited earlier with regards to the experienced effects of technological distance. In the first case, the interviewee reported that he did not feel *'properly informed' (IP 43)* about important technical issues, as the partner presumed a certain degree of understanding. Thus, frequent email exchanges and telephone calls were sought in order to establish a basic comprehension and dispel misunderstandings. However, according to the interviewee, these frequent loops did not fully make up for face-to-face meetings. Over time, the firm resorted to a certain degree of passivity, hesitating to contact the partner each time a question arose but first trying to make sense of the pieces of information on its own. However, this was time-intensive, counterproductive and often resulted in despondency. In the second case, the interviewee reported that their partner frequently experienced problems with the new technology, but *'struggled to formulate his problems' (IP 37).* Consequently, employees of the focal firm had to invest considerable time in traveling to the partner in order to inspect the problem on site, which at some point evoked a negative perception by the concerned employees, as expressed ironically by one interviewee as *'win a ticket' (IP37)* to the US.

Furthermore, while a higher frequency in the communication loops and occasional face-to-face meetings were eventually sufficient to share results and co-ordinate the work plans, it did not suffice if the firm intended to learn from the partner. This was reported by another firm, which reported that it had failed in its aspiration to learn from its US university partner. The firm concluded that next time,

> *'one employee needs to be there on site for four weeks in order to learn the methods' (IP15).*

Together, the quantitative and qualitative findings generally confirm the suggested indirect effect of geographic distance (hypothesis 8a). Furthermore, it turns out that the strongest effects have been revealed for the dimensions of organisational and technological distance, which conforms to hypothesis 8b. Only with regard to the institutional dimension, the relationship that was assumed in hypothesis 8b could not be established empirically. However, the prior analysis has shown that it is not primarily differences in language and cognition that hamper co-operation when the partners are organisationally different, but rather different organisational styles and incongruent schedules that render the partner's actions intransparent and incomprehensible.

The respective interaction results for the **relational dimension** are presented in table 8.25. In the original model in table 8.21, the coefficients of relational distance in regard to goal achievement suggest an inverted U-shaped relationship between the variables, although the variability in the data was too high to produce statistically significant relationships. One explanation for this weak result has been suggested to lie in the indirect nature of the dimension, which supports the alignment of structural and cognitive or knowledge differences through previous investments and conveys trust among the partners. Thus, relational proximity can eventually mediate the problems faced in co-operation projects that are characterised by high levels of organisational, institutional and technological distance.

However, it needs to be reconsidered that the sample co-operation projects displayed low levels of prior acquaintance; i.e., relational proximity. Thus, it was suggested that prior investments in the alignment of structures (organisational proximity) and knowledge and cognition (technological/institutional proximity) could mostly not have been established so far.

Likewise, the results of the interaction model in table 8.25 show only one statistically significant interaction effect in model III: according to the model, there is a positive interaction coefficient between relational and organisational distance ($p<.10$). In this model, the explanatory power of the regression model also improves with a higher value for R^2_{pseudo} and a lower value Prob > Chi^2.[35]

Thus, while both single coefficients of organisational and relational distance were not significant in the original model, their interaction term is positive and significant. Besides, the single coefficient of organisational distance becomes significant. Thus, when controlled for the interaction effect between organisational and relational distance, organisational differences turn out to have a negative effect on goal achievement. However, with increasing levels of relational distance, it seems that the partners take more time to take provisions against these eventual negative effects of organisational distance. By contrast, when the partners are acquainted before, the result suggests that they take less care in designing detailed contracts and work plans that in the end do not pay off. Thus, one explanation might be that projects tend to be governed less stringently when personal relationships are at stake, which has a negative impact on the course and outcome of the co-operation project. The latter explanation has been forwarded by one interviewee who was discontent with a partnership that was based on an indirect personal contact. This personal obligation led to a rather loose contractual and operational governance structure and

[35] The coefficients of the control variables remain again largely unchanged and are not reiterated here.

Table 8.25: Interaction Effects: The Indirect Nature of Relational Distance

	I	II	III	IV	V
Geographic distance	0.35	-0.12	-0.07	-0.05	-0.09
Institutional distance	1.91*	2.89†	1.69†	1.87*	2.02*
(Institutional distance)^2	-0.42*	-0.43*	-0.36†	-0.42*	-0.45*
Organisational distance	-0.01	-0.00	-2.29†	0.01	0.01
Strategic distance	-0.23†	-0.22†	-0.15	-1.66	-0.23†
Technological distance	2.09**	2.12**	2.26**	2.33**	3.00*
(Technological distance)^2	-0.49***	-0.50***	-0.53***	-0.53***	-0.52***
Relational distance	0.41	1.10	-4.29	-0.92	0.23
(Relational distance)^2	-0.03	-0.06	0.39	-0.00	0.04
(Relational distance) · (Geographic distance)	-0.10				
(Relational distance) · (Institutional distance)		-0.22			
(Relational distance) · (Organisational distance)			0.51†		
(Relational distance) · (Strategic distance)				0.32	
(Relational distance) · (Technol. distance)					-0.16
Firm size	0.00*	0.00*	0.00*	0.00*	0.00†
Firm age	0.02	0.01	0.01	0.00	0.00
R&D intensity	0.10	0.09	0.06	0.05	0.05
R&D breadth	-0.11	-0.13	-0.20	-0.21	-0.16
Network centrality	-0.14	-0.07	-0.13	-0.04	-0.05
Duration	-0.24	-0.26	-0.17	-0.28	-0.25
Inv. stage	0.54†	0.53†	0.60*	0.54*	0.48†
Learn. rationale	0.19	0.18	0.07	0.21	0.20
Constant	-0.10	-2.59	12.82	5.38	-0.80
Sigma constant	0.50***	0.49***	0.48***	0.49***	0.49***
No. of cases	39	39	39	39	39
log-likelihood	-26.20	-25.88	-24.66	-25.34	-25.98
Chi^2	43.86	44.50	46.93	45.58	44.29
Prob > Chi^2	0.0006	0.0005	0.0002	0.0003	0.0005
R^2 pseudo	0.46	0.46	0.49	0.47	0.46

† p<.10, * p<.05, ** p<.01, *** p<.001

an avoidance of open conflict that did not lead to an efficient, satisfactory project outcome; a situation that often *'happens in my experience when a partnership strongly builds on prior personal relationships' (IP25)*. This result is contrary to the expected hypothesis of accumulated social capital between the partners that is assumed to be beneficial for a partnership.

Thus, hypothesis 8a which postulates an indirect impact of relational distance, could not be confirmed. There was only one significant relationship between relational and organisational distance. Hence, hypothesis 8b on a higher relative interaction effect for those dimensions that are directly related to knowledge and cognition also needs to be dispelled. While there is indeed an interaction effect between relational and organisational distance, this effect is rather related to the co-ordination of incompatible incentives, priorities and work organisations than to knowledge sharing.

8.4 Summary and Conclusions

This chapter has offered an extensive, cross-case empirical evaluation of the impact of distance in different dimensions in 39 international case co-operation projects from German dedicated biotechnology SMEs. The analysis has been based on personal interviews with key informants based on a semi-structured interview guideline. Thus, numeric and narrative data has been collected simultaneously which has been evaluated separately but combined in the presentation and interpretation of the findings.

The sample of case co-operation projects is composed of inter-organisational research as well as development projects. Within these, access to complementary resources or new insights and techniques is the most important driver to integrate an external partner. For some firms this is further accompanied by the quest to learn from the partner, while for others learning is of subordinate importance. While learning is a constant activity in this science-based industry, learning *with* the partner was sometimes perceived to be a more appropriate description than learning *from* the partner (see section 4.6.2). In this case, both partners focus on their distinct specialised knowledge and capabilities that they temporarily combine to solve a particular problem or explore a new field in order to generate new or enhanced products, processes or services.

Overall, the firms in the sample display a high share of international co-operation projects, with more than half of the five most important project partners coming from abroad. These partners are mostly located within the Triad, foremost within Europe and central biotechnology hotspots in the USA. While considerable variance exists with regard to the geographic distance between the partners, this regional concentration also explains the relatively low mean level of institutional distance that has been reported by the interviewees. Whereas the whole scale range has been used in regard to organisational distance, it stands further out that the mean degree of strategic distance is rather high. Also in regard to technological distance, it turns out that the interviewees reported a wide range of differences from their personal judgment. However, these differences are often found within the confines of a closely delineated research field (relatively low mean value of the construct technological distance). The mean value of relational distance is the highest. Hence, contradictory to social network studies, the interviewees indicated that most co-operation projects were not based on previous partnerships, personal acquaintance or common third parties, but were started from scratch.

Contrary to the theoretical suggestions in section 4.5, a bivariate correlation analysis revealed no important inter-relationships between the expressions of distance in different dimensions. The only exception is a weak correlation between organisational and strategic distance ($p<.10$), which suggests that organisationally different partners tend to pursue different strategies or are often not perceived to be competitors. Thus, a variety of different combinations of expressions of distance in different dimensions have been found in the empirical sample. Furthermore, there are few differences in the reach of the projects according to the invention stage or the learning rationale. One interesting finding is that co-operative research projects are characterised by higher levels of (perceived) technological distance between the partners, compared to collaborative development projects. This finding indicates a greater quest for variety to yield novel combinations in these projects. Moreover, the results of the statistical comparison further suggest that research projects are more often pursued with partners that are acquainted prior to the focal co-operation project (lower values of relational distance). Thus, co-operative research projects are sometimes triggered by ‘know-who’; i.e., personal knowledge of people who are involved in front-end research. Finally, it seems that firms who aim to learn from their partner tend to avoid high levels of institutional distance.

The main part of this chapter consisted of the measurement of the impact, relative weight and interplay of distance in different dimensions on the attained level of success of the project in regard to goal achievement and a further set of outcome categories. A multivariate model based on a Tobit regression has been core to the analysis. Based on this, the qualitative data has been used to complement, explain and extend the quantitative insights. In particular, key moderating variables and effects of distance for each dimension have been identified that complement the quantitative assessment. Table 8.26 summarises the main insights from the quantitative and the qualitative analyses. In the second column, the table aggregates for each dimension of distance the key moderating variables that have been identified from the interviews and that moderate the actual impact of each dimension.[36] The third column summarises for each dimension the revealed effects of distance from the regression analysis with respect to the global success measure 'goal achievement'. It presents the respective sign of the relationship and its level of significance. The reported effects as perceived by the interviewees are summarised in the last column. In this column, a (+) indicates a positive effect, a (–) indicates a negative effect, and a (∼) implies that no clear evaluation of the effect has been given by the interviewees.

Without repeating the findings in detail – for this see table 8.26 – the most striking effects have been observed for technological distance, followed by institutional distance. In both dimensions, an inverted U-shaped relationship in regard to the dependent variable goal achievement has been confirmed with increasing levels of distance. Thus, the hypothesis that those dimensions that are closely linked to knowledge and cognition exert the greatest impact, positive as well as negative, on inter-organisational co-operation projects in R&D has been corroborated. Both technological and institutional distance are sought to access varied resources that fill resource gaps or deliver new insights and approaches. However, after a threshold level that is conducive for the project, the novelty potential of technological and institutional distance can be overshadowed by difficulties in knowledge sharing. In both dimensions, interviewees reported incidences of misunderstandings or misinterpretations caused by high degrees of distance in knowledge and cognition between the partners.

[36] The moderating variables that were addressed in the interviews confirm many of the indicators that had been defined for this study, e.g., the importance of accessibility versus geographic distance in a metrical sense. Others, e.g., the global imprint of the firms, could be added. Other moderating variables, such as the great role of global epistemic communities characterised by a shared scientific culture and methodological approach, might be specific to global science-based industries such as modern biotechnology.

Table 8.26: Summary: Moderating Variables and Distance Effects

	Moderating Variables	Effect Size[1]	Effects
Geographic distance	perception/sensitivity; accessibility/time distance (physical, virtual, personal)	(-)	(+) quality (-) misunderstandings, irritations, uncertainty, learning, intransparency, delays, loss of control, relationship-building, (costs)
Institutional distance	(global) epistemic communities ('epistemic culture'); international 'imprint'; lingua franca; meta-institutions (e.g. EU)	(+)†/(-)*	(+) new insights (uniqueness) (-) misunderstandings, irritations, misappropriation concerns, accustomisation time
Organisational distance	shared scientific approach; projectification; experience/anticipation	(-)	(-) goal incongruency, incongruent incentives, structural incompatibilities, disagreements, irritations, dissatisfaction, delays, intransparency
Strategic distance	professional ethos (loyalty); specificity of knowledge; knowledge dynamics	(-)†	protection strategies: (∼) avoidance (exit); trust (loyalty); contracting, demarcation, conscious knowledge sharing (voice)
Technological distance	knowledge redundancy; knowledge brokers	(+)**/ (-)***	(+) complementarity, synergies, learning (-) lack of codes, incomplete assumptions, naivety, misunderstandings, impatience, lack of respect, buck-passing
Relational distance	reputation; personal judgment/affection ('trust as default')	(+)/(-)	(∼) demarcation, (-) hesitation, gradual opening, increased time

[1] with respect to goal achievement

† $p<.10$, * $p<.05$, ** $p<.01$, *** $p<.001$

These difficulties that have been reported in respect to technological and institutional distance are primarily related to the ability of the partners to share knowledge, although they in turn exert a negative effect on the motivation to do so. The other dimensions of distance are inherently more related to motivational factors, which step back against cognitive difficulties in inter-organisational knowledge sharing. Thus, geographic, organisational and relational distance were themselves no strong predictors of goal achievement as well as the other outcome categories. Only strategic distance was found to exert a significant negative effect on goal achievement, which has been explained by a lack of tension or pressure within the project in the absence of competitive risks. Conversely, the interviewees did not report strikingly negative effects from strategic proximity, which they primarily attributed to a high degree of dynamism and the niche character of modern biotechnology business as well as a reliance on the partner's loyalty and discretion. A similar pattern is observed for the trust dimension of relational distance. In an industry that is characterised by the need to rely on various external sources of knowledge and capabilities, 'trust by default' has evolved as a mechanism that makes frequent projects with changing partners possible at all.[37] Organisational distance often represents a psychological barrier and a source of group thinking. However, it can also be the source for more fundamental problems such as incompatibilities in incentive and organisational structures, which can lead to delays, a lack of insight (intransparency) and control, and eventually the pullout from the project by one or both partners.

Against expectations, geographic distance itself is no predictor of the difficulties that are faced in inter-organisational co-operation projects. However, coupled with high levels of technological or organisational distance, the geographic separation of the partners constitutes a liability, shifting the overall potential of the project downward or increasing the likelihood of inter-organisational conflict. Thus, within a narrow epistemic community, global co-operation is not problematic, but conducive to invention. However, the interaction effects have revealed that with increasing differentiation in knowledge and techniques between the partners, high levels of geographic distance can constitute a liability that makes integration and co-ordination between the partners more challenging. Likewise, when a geographically distant partner displays high levels of organisational distance, intransparency and delays can be fueled that together exert a negative impact on the success of the co-operation.

[37] Of course this does not substitute for contracts and is supported by high degrees of knowledge protection through patents; these, however, cannot completely rule out the risks inherent in inter-organisational co-operation.

The relational dimension is one marked exception. It has been suggested that the existence of close relational ties can help to level out problems in knowledge sharing through prior levels of experience or convergence in knowledge and structures; yet, at the expense of novelty. However, except for the organisational dimension of distance, the expected inverted U-shaped relationship could not be established. One reason might be the initially low levels of relational proximity found in the sample where convergence in knowledge and respective inter-organisational routines have not yet been established. Given the transient nature of a project and changing resource needs, it is questionable whether there are many situations in which firms can truly exploit the suggested cognitive and structural benefits of social capital in this industry.

9 Case Studies: Organising Proximity

9.1 Overview

In this chapter, the extensive, cross-case analysis of Chapter 8 is complemented by the intensive, detailed study of three selected case projects. It serves to

1. explore the process of inter-organisational co-operation, incorporating the time aspect, and to gain new insights into **management responses** to achieve proximity within the inter-organisational team;
2. explicitly pay attention to potential differences associated with the suggested **intermediating variables** – invention stage and learning rationale – with regard to organisational challenges and responses.

Knoben and Oerlemans (2006) claim that 'organizations that start in an IOC [inter-organisational collaboration; comment by the author] should be prepared to invest in building organizational proximity' (p. 86). Thus, the purpose of the case studies is to get an idea of how firms respond organisationally to the challenges of collaborating across distance; given the time and resource restrictions characteristic for a project. Through this, the insights from Chapter 8 are deepened and expanded; paying attention to the 'inter-organizational dynamics' (Doz, 1996, p. 80) setting in. This is best addressed through case descriptions where specific attention can be paid to time and context and a larger set of variables can be included (Yin, 2003).[1]

Moreover, it has been suggested that the invention stage of a project as well as the pursued learning rationale might influence the impact of different dimensions of distance within inter-organisational co-operation and thus determine adequate

[1] Doz (1996) justifies his choice of a case study approach for the exploration of the process of inter-organisational co-operation by stating that this approach is 'useful when exploring a relatively unknown phenomenon, in which the unfolding of events over time plays a key role' (p. 80).

J. Hartig, *Learning and Innovation @ a Distance,*
DOI 10.1007/978-3-8349-6904-0_9,

management responses (see section 4.6). Both aspects are explicitly addressed in this analysis.[2]

This introduction is followed by an outline of the selection of the case studies (section 9.2). In section 9.3, the three selected case reports are presented. Section 9.4 includes an analysis of each case study and a cross-case analysis, opposing the case studies to expound on similarities and differences in each case. In the remainder, summary conclusions are drawn and a set of generic management responses is designed (section 9.5).

9.2 Selection of Cases

The cases are derived from the overall sample of case co-operation projects. The selection of the cases followed a stepwise procedure. The first filtering criterion was given by the characteristics of the case projects in regard to their invention stage and their learning rationale. These two dimension span a two-dimensional matrix in which the projects are positioned (figure 9.1).

The majority of the case projects is located in quadrant D (30%). These are projects which pursue collaborative development with no strong intent to explicity learn from the partner. Another 27% of the case projects are located in quadrant A, which includes projects that pursue research activities and where the intent to learn from the partner is explicitly given. 22% of the projects are located in quadrant B; i.e., projects which are classified as collaborative research, but where the intent to learn is less pronounced and the firms indicated that access to the resources of the partner is their prime quest for engaging in inter-organisational co-operation. Of lower occurence are projects in quadrant C (21%); i.e., development projects where the focal firm wants to learn from the partner. From each of the thus delineated groups – except for quadrant D which comprised less cases and which would not yield additional insights, as both dimensions research versus development and weak versus strong learning rationale are already covered by the other three quadrants – a case project was chosen. In a second step, the actual selection of the cases was based on their capacity to provide in-depth insights into organisational responses and where the interviewees accepted the publication of the case material.

[2] Due to the relatively small number of cases, it has not been possible to split the sample into sub-groups to test the hypotheses within the multivariate analysis presented in Chapter 8.

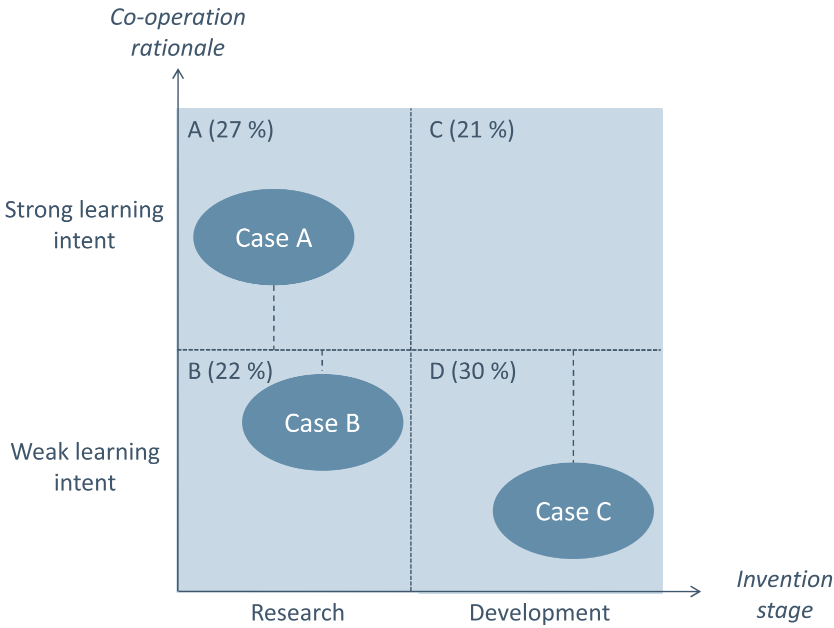

Figure 9.1: Framework for the Selection of Cases

Based on these considerations, three case co-operation projects have been selected, which are situated in quadrants A, B and D of the matrix in figure 9.1. Case A represents a case co-operation project which is qualified as early research, where the focal firm pursued an explicit learning intent. Case B is an applied research project where the partners aimed to combine their specialised expertise and profit from the resulting division of labour. Case C is a development project which also aimed to capitalise on the combination of distinct capabilities where no firm specifically aimed to learn from the other.

9.3 Case Studies

In the following three sections, each of the case studies is described. The description of each case proceeds in three steps, comprising a general portrait of the firm; an outline of its general co-operation strategy; as well as an in-depth description of one international inter-organisational co-operation project in R&D, which forms the main part of the case description. It concentrates on the the perceived influence of distance in different dimensions and explores the respective organisational responses, which the firms implemented in each of the constellations defined in matrix 9.1.

9.3.1 Case A

The goal of this case study is to demonstrate the challenges which co-operation in early research (in this case early feasibility tests) pose in a firm's quest to be constantly aware of and learn about new knowledge and techniques which might affect its technological niche in the future and which might underpin the firm's global technological lead; focusing thereby on the different dimensions of distance and how the firms responded to them.

Company Profile

The focal biotechnology firm is active in the field of cell technologies, products and applications, such as regenerative medicine. On the basis of its core proprietary technology, it pursues a dual business model, being both a product company as well as a service provider. Its products and services are targeted at both, commercial firms and research organisations. Despite a strong focus on R&D, the firm is a fully integrated biotechnology firm, fulfilling all of the value chain activities in-house.

Correspondingly, the firm already generates revenues of which it reinvested in 2008 a share of 10 to 20% in R&D. Its R&D activities serve primarily to develop new products or enhance its existing ones. As products and technologies are closely coupled in this field, new as well as enhanced technological solutions are likewise sought. Besides, its R&D activities aim at the generation of new IP, the realisation of lower costs for its existing products and technologies, as well as the advancement of potential service or organisational innovations. The internal R&D base is very broad in numbers and skills. Thus, the firm employs researchers from biological and chemical disciplines, including immunology, cell and molecular biology, haematology, regenerative medicine, chemistry through to physics and engineering, including biomedical, electrical, plastics and software development.

General Co-operation Approach and Geographic Reach

Next to its own investments in R&D, the firm is constantly involved in a large number of co-operation projects. These can be divided into two basic types of partnerships. First, the firm engages in co-operation projects with primarily academic partners. The aim is to learn about new products or techniques early on in order to be a prime mover in the generation and commercialisation of new or enhanced products and technologies and to remain a leading player at the scientific frontier. Second, the firm invests in partnerships with medical doctors in hospitals in order to evaluate new cellular therapeutics.

As knowledge in biotechnology is produced globally, the goal to remain the world-wide leading player demands a global reach of these co-operation activities. Furthermore, the firm aims to integrate renown opinion leaders and multiplicators in order to leverage the global exploitation of its technological base. Thus, the geographic reach of these co-operation agreements is

> *'global. … Of course one always prefers geographic proximity, but the quality is more important than geographic proximity.'*

Geographic proximity is not perceived as a necessity. However, according to the interviewee, it facilitates co-operation, rendering it more efficient at times.

Case Co-operation Project

The firm is constantly alert in respect to new developments within its major and also related market and technological areas in order to secure its status as a leading-edge supplier in the field of cell technologies. Thus, it constantly monitors the world-wide research and development activities within the private and public domain. This was also the ignition for the case co-operation project.

Building on its far-flung network of ties, the firm got early notice of a new method which promised to bear potential to complement and extend the company's current product portfolio. Hence, it approached a Suisse-based university group with sound expertise in the field of proteomics and system biology to enter into an early-stage research collaboration project. The research group was pursuing a new technological approach to identify proteins at the surface of cells which

> *'is not such a standard technology which can be found in a thousand locations worldwide; instead it is relatively unique.'*

This technology promised to identify proteins at the surface of cells which might be used as new markers within the firm's proprietary technology in order to identify and separate cells. The adoption of this new technology could contribute to broaden the firm's product portfolio and strengthen its future technological lead. However, the validity of the technology was not yet proved which increased the level of uncertainty of the task. Correspondingly, the goals of the co-operation project were two-fold. They comprised

- the validation of the technology (scored 5); and based on this
- the identification of new target structures for cell separation (scored 5).

The firm expected high synergistic benefits from a coupling of its expertise in cell technology with the partner's expertise in proteomics and systems biology. Moreover, the co-operation project was motivated by the desire to learn about this emerging research field and the partner's technology and eventually absorb it into the firm's internal technology portfolio. Access to new knowledge and skills, the realisation of potential synergies, the desire to learn from the partner and through this, the securing of an early stake in a promising new technology were likewise of importance in this co-operation project.

To leverage this potential, the partners had to master a geographic distance of slightly more than 400 kilometers, corresponding to a travel time of 2.5 to 3 hours by plane, measured from site to site. Hence, the accessibility of the partner was perceived as convenient. Furthermore, the partner was also perceived as very similar in regard to its regulatory context, its national culture and native language.

Turning to the partners' organisational characteristics, larger differences were reported. According to the interviewee, these could be primarily ascribed to differences between public and private organisations, their basic orientation and the way these different organisational types are structured and operate. Two essential points were mentioned. First, having a university as contractual partner made the contracting phase protracted and more difficult. Second, in regard to working conditions, styles and approaches, the university differed markedly from the firm. This was most evident in the way the work was prioritised and scheduled. The project was foremost affected by PhD and post-doctoral students, who were driven by their own research interests. Further, high degrees of fluctuation in public research organisations were perceived as a general drawback in the successful and timely realisation of firm–university collaboration projects. Nonetheless, compared to the interviewee's experience from other previous university collaborations, this specific partnership was evaluated as relatively well structured.

However, these differences in structure and goals were beneficial in that no direct competitive threats were perceived by the interviewee. The knowledge bases and future aspirations of the partners were compatible and rather complementary. The output of the co-operation would be used in different ways by the partners; the firm seeking to exploit the knowledge and techniques commercially by implementing them into its existing technological base; while the university group was primarily interested in the exploration of basic structures and functions of cells. The university's prime motivation to engage in collaboration was to demonstrate the validity of its technology with a sound industrial partner and to raise the broader awareness for its approach through a series of joint papers and presentations. Indirect links to other firms or research groups which might pursue similar commercial goals as the focal firm might have existed, however

> *'This is a matter of trust. ... Other partners, they are involved in many partnerships simultaneously ... Then you can't handle everything as openly. Then you have to contractually hedge, confidentiality agreements, these things. Or, if you want to make sure, you have to drop the whole thing.'*

In this specific partnership, the partner was perceived as trustworthy and the risk of knowledge leakage as correspondingly low. This high level of instant trust in the partner was also due to the prior personal acquaintance between the firm and the university group; although prior encounters were up to then rather informal and loose.

Corresponding to the quest to explore a new field, the knowledge bases which were combined in the co-operation project were perceived as highly complementary with little overlap in expertise. As judged by the interviewee:

> *'Principally, this co-operation project is specifically complementary in terms of interests, technical know-how and basic knowledge. Of course we have a certain amount of shared understanding, just like two medical practitioners; however, when an ear, nose and throat doctor meets a gynaecologist, these are however different worlds.'*

The prime knowledge base of the partners built on biological knowledge, with a large part of the employees being trained in biology. Yet, the partners had adopted very different specialised trajectories in this field. While the firm had built up leading expertise in cell technologies, the partner possessed specialised experience and expertise in proteomics and systems biology. The interviewee assumed that, in case this basic understanding in biology had been missing, the co-operation project would have been much more difficult. This suggestion built on the interviewee's experience from other constellations of inter-disciplinary work. For example,

> *'chemists or engineers have much less understanding for biology and our applications. We experience this [difficulties in communication and comprehension] internally, here at [our firm].'*

According to the interviewee, these difficulties in mutual understanding when different disciplinary backgrounds meet are one reason why the firm generally does not reach out farther to distant bodies of knowledge and expertise in inter-organisational co-operation projects. Most generally, co-operation partners tend to be trained in biology and medicine which mirrors the firm's prime internal knowledge base. Compared to other co-operation projects, the focal co-operation project was marked by relatively high levels of technological distance according to the interviewee.

Contractually, the goals of the co-operation project were fixed formally. However, the contract included enough leeway for eventual adaptations and extensions of the partnership. This loose structure was necessary as the results of the project and future potential applications were at that time rather speculative and not foreseeable. Furthermore, a trans-organisational team was composed, consisting of approximately twenty people, with about ten people from each partner. On the part of the focal firm, this comprised specialists from different cell types.

Operationally, in line with the goals of the project, the main task consisted of the validation of the technology. For this purpose, the focal firm determined cells of different types as test units, which it separated and shipped to the partner. The partner then took over to apply his novel technique to identify the surface proteins of the respective cells. The results were transferred back to the focal firm and discussed between the partners. These exchanges of cell lines and data took place in an iterative manner. Nonetheless, although divided into distinct steps with distinct responsibilities of the partners, this process necessitated a close integration of the sub-teams, which together interpreted and discussed the results and devised the next steps. Inter-organisational communication and co-ordination was primarily effected via ICT. Email and telephone were the prime media for communication. Newer media such as video conference or shared databases were not used.

Nonetheless, communication with the partner, especially via ICT, proved not to be a straight-forward task and afforded investments in learning, particularly on the part of the focal firm. That is to say, a requisite level of understanding regarding the content of the data which was transmitted was to be achieved first:

> *'The results [of the tests] are datasheets; and the way of presentation and the interpretation of the presentation needed to be learned. System biologists have found ways to present their huge amounts of data, which needs to be understood first. This whole experience ... If I was to look at them [the data] for the first time, it would take a while for me to get the point what all the data means.'*

Thus, despite a standard format for data transmission, initial training to become acquainted with the formats and codes of the other's field was necessary at an early stage of the project for the co-operation to work.

However, after initial investments in learning, geographic proximity was not perceived as a necessary prerequisite, as most of the communication between the partners was electronically. According to the interviewee, geographic proximity is

> *'nice to have. It makes things more efficient. However, it would also work if it was Boston or New York. [Nonetheless,] if one wants to experiment together, to see things, show things, this does not work electronically.'*

Additional face-to-face meetings took place approximately four times a year. These face-to-face meetings varied in terms of length from one day trips to a whole week spent with the partner. Even more, the co-operation project benefited from the fact that one employee from the firm was seconded to the partner's site to be able to permanently work with the partner. This way, she could experience the possibilities and limitations of the technology personally and learn how to handle it:

> *'... our colleague learns all the steps of the procedure there. ... She learns it, because she is supposed to learn it for us so that she can do it later already when we want to apply it [the technology; comment added] here. If we wanted to invest in it, then we would have the opportunity to implement the technology here with somebody who is already familiar with it. ... Otherwise, the technology transfer would be realised through hiring somebody who graduates there.'*

In this case, the possibility for the employee to stay on site was not purposefully sought but a *'lucky coincidence'* according to the interviewee. Nonetheless, the firm realised that the project benefited from the fact that she was permanently on site to observe and learn the process steps in direct interaction with the partner. Particularly as the ultimate goal was to learn about the technology and to adopt it in case it proved valid, this close interaction and the possibility to observe and learn from the partner significantly eased the co-operation and supported the realisation of the project's goals.

The permanent physical presence of the employee throughout the project was also helpful to mediate other distance problems, namely those expected from the high level of organisational distance between the partners. One problem in inter-organisational co-operation with universities was said to be their diverging goals, priorities, managerial styles and work organisation. Hence, by having one person on site, continuity and alignment of work progress were guaranteed.

> *'Academic research ... works like this: there is a boss, group leader or professor, a host of scientists who focus on their master or PhD thesis, post docs or careers and not so much on the co-operation project, and some technical assistants. ... From this perspective, if you have somebody on site, the one can prevent that things sink too much into oblivion.'*

Furthermore, trust into the results as well as into the partner was increased through this intense personal experience with the partner:

> *'One has higher levels of trust into the results when someone [from the own company; comment added] is on site compared to when a PhD or master student is doing it. ... Then we do not know, does the technology not work, or is it just...?'*

The co-operation project lasted for more than one year. Over this extended period of collaboration, the firm realised that the technology was not yet fully developed to be commercially used. Further research efforts would be needed and the decision to invest in its adoption was delayed at that point. This was also due to the very early state of knowledge in this field. At the time the co-operation was launched, *'there was world-wide not enough experience [with it]'*. Nonetheless, the prime goal of testing for validity was fulfilled and the firm is reassured that it keeps up with a promising emerging technical development. In terms of achieving its strategic goals of being the prime mover when new technologies emerge and to not miss out novel approaches or even leave the field to competitors, the co-operation was a necessary step from the point of view of the firm. Furthermore, important new knowledge was gained through the combination of knowledge and skills in a newly emerging research area. Thus, the learning effects through the collaboration were rated as high. Moreover, the co-operation project resulted in a number of jointly published articles and conference presentations. Also personally, the interviewee and his team were content with the co-operation and the partner's performance. The researchers involved enjoyed exploring this new field of knowledge and the trusted relationship in regard to both the competences and behaviour of the partner was strengthened.

This was not least due to the fact that a close personal relationship was built through the employee who spent the whole time on site with the partner.

9.3.2 Case B

This case study is a prototypical case of the division of inventive labour between a dedicated biotechnology firm and a large multinational company. The co-operation project is primarily about joint applied research; although subsequent development steps were also included in the contract. Both partners were specialists in a certain field and aimed to combine their expertise without the immediate intent to (out-) learn the partner.

Corporate Profile

The focal firm was founded already in the early 1990s and meanwhile represents one of the leading medium-sized dedicated biotechnology firms in Germany. It upholds various sites in Germany and abroad; primarily in the UK and the USA.

The company concentrates on the development of therapeutic proteins, based on its proprietary technology. It is organised in two lines of business. The first line concentrates on the development of therapeutic proteins for external partners as well as its expanding internal product pipeline. The second line of business consists of the sales of standardised proteins to research groups. Thus, the firm pursues a hybrid business model, offering customised solutions, standard services and at the same time seeking to develop its own line of therapeutic compounds. Its core business activities are found in applied research and development. Its compounds are used within the research, pharmaceutical and diagnostics industry.

Corresponding to the firm's business model which centers primarily on research and development, the firm is highly research intensive and reinvested in 2008 between 10 and 20% of its revenues in R&D activities. The prime goal of these activities is the generation of new products in the form of new therapeutic compounds based on the firm's proprietary technology. Besides, the firm aims to constantly improve and expand its base technology with new techniques, contents and features. In the period from 2003 to 2008, the firm operated more than ten R&D projects.

General Co-operation Approach and Geographic Reach

The firm's co-operation approach corresponds to its business model and its main R&D activities. First and foremost, the firm's business model is essentially partner-based. In recent years, the firm has incurred numerous R&D partnerships with well-known multinational companies from the pharmaceutical and biotechnology industry in order to jointly identify and develop proteins for research purposes or as therapeutic or diagnostic compounds. Besides, the firm is integrated in a network of universities and SMEs with the goal to in-license new technologies or patents for its internal R&D projects or to jointly advance the firm's technological base.

The first type of inter-organisational co-operation agreements is primarily motivated by the need to combine complementary resources and skills of the partners, as well as to realise synergies. The agreements are based on a division of labour between the biotechnology firm and usually large pharmaceutical partners. Learning from the partner is not a prime quest in these agreements and is only indirectly achieved through the additional experience gained within the collaboration, which helps the firm to further advance its base technology. A subsidiary motivation for collaboration from the perspective of the focal firm is to establish its technological base as an industry standard. The second type of co-operation projects serves to monitor the research and technological frontier with the aim to be early involved in new techniques to keep the own technological base on the leading-edge, as well as to fill the internal pipeline with promising new compounds. Here, learning is of higher weight compared to the division of labour between the focal firm and large MNEs as found in the first type of agreements.

In both types of co-operation, the geographic reach of the partner network is generally not restricted according to the interviewee. Particularly in regard to the first type of R&D partnerships with mainly large, commercial partners, the geographic location of the partner was said to be irrelevant. Other factors were said to dominate, such as the partner's capacity and resources to deliver target structures and to advance the project, as well as comparable *'mindsets'* of the partners, expressed by the interviewee as the partner being *'on the same wavelength'*, and the level of trust into the partner. In the case of geographically distant partnerships,

> *'we manage to establish as much proximity within the co-operation as necessary in order to realise the goals.'*

However, for the second type of co-operation agreements, which are closer to the exploration of new knowledge and skills, geographic proximity was said to be preferred. This is partially due to differences in the goals and characteristics between the two types of agreements. In the latter type of exploration projects, proximity is preferred as

> *'you can quickly go there [to the partner] in order to actually try things out or figure things out in the lab.'*

To proficiently organise its portfolio of co-operation partners, the firm has established a dedicated alliance management unit. This unit constitutes the central link between the firm's R&D unit and its business development unit as well as the link between the focal firm and its external partners. Thus, the alliance management unit constitutes the key interface between the strategic aspirations of the firm and its operational implementation. It is also mainly involved in the case co-operation project which is outlined below.

Case Co-operation Project

As case co-operation project, a partnership from the first type of agreements has been chosen. Starting off in the mid 2000s, the focal firm entered a research and development agreement with a European multinational pharmaceutical company. Under this agreement, the pharmaceutical partner identifies new potential therapeutic targets and seeks the focal biotechnology firm's excellence in the development of new therapeutic compounds based on its proprietary technology. The framework contract includes fixed payments as well as milestone related payments and royalties on the side of the pharmaceutical firm over the lifetime of the agreement for the development of new compounds.

This framework agreement is operated in a number of distinct projects which are run by joint project teams from both companies. These projects usually last between 12 and 24 months and comprise teams of up to ten people, composed evenly with members from each partner organisation. The pharmaceutical partner is a multinational company with R&D sites and dedicated research units spread across the globe. Thus, one specificity of this partnership is that the teams and locations change with the projects. Wherever potential new therapeutic targets emerge within the MNE's internal research network, the project teams are newly composed according to the origins and necessities of the respective project. Hence, although the different projects follow similar goals and patterns, they all display differences in the team's composition and location.

One of the earliest projects between the partners which is now close to finalisation, was run with a research group located at the east coast of the USA. The project lasted for 1.5 years and was classified by the interviewee as an applied research project geared at the generation of a new product; i.e., a new therapeutic compound. The goals of the project were

- the identification and development of a new therapeutic compound (scored 5); and adjacently

- its joint predevelopment, implying the successful entrance of the compound into clinical trials (scored 4).

To realise these goals, a dedicated project team consisting of five to ten members – split half between the partner firms – was composed.

As mentioned above, the sub-team from the partner was located at the MNE's R&D site in the USA. To reach the members from the trans-organisational team for face-to-face meetings would have taken about eight hours; and a time lag of six hours compared to central European time existed between the partners. Nonetheless, the accessibility of the partner compared to other partners was evaluated as satisfactory with a good travel infrastructure connecting the German and the US site. However, as is shown later, the places for face-to-face meetings were not restricted to the locations of the respective team members.

The level of institutional distance between the German sub-team and the partner's team members in the USA was perceived as low. Both countries were perceived as rather similar in regard to their institutional set-up, including the cultural background of the people. The business language was English which constitutes the general 'scientific language' and which was mastered properly by both partners.[3]

Despite considerable differences in the overall size and structure of the partners, both firms' R&D units were organized primarily in dedicated project teams. Thus, despite differences in regard to structures and processes at higher organisational levels, comparable units in the form of project teams met in the co-operation which resembled each other in regard to their structure, composition, dynamics and culture with the people being used to project work in often rotating teams. According to the interviewee, this similarity eased the process of collaboration. On an aggregate level, however, differences in goals, time lines and reward structures became evident; for example in regard to the prioritising and sequencing of projects. This was broadly fixed in an overarching work plan; however, it also had to be broken down into day-to-day operations across the organisational boundaries. Different priorities and schedules eventually led to frictions, incompatibilities and frustrations. However, the recognition for timely and repeated communication of one's own schedule, expectation and needs was learned by the partners and needed to be respected by both partners. Furthermore, a congruent structure, particularly the existence of an alliance management function on both sides which adopted a *'helicopter view'* and represented an escalation step in the case of conflict was perceived as helpful in the operation of the project, as well as for the overall framework agreement.

Considering the biopharmaceutical value chain, both partners were rather vertically positioned vis-à-vis each other and possessed complementary resources and capabilities. Thus, the interviewee assumed that no direct competitive threat was existent. Besides, an indirect drain of knowledge to competitors was also not feared due to the highly specific nature of the knowledge and expertise. If this high specificity was not given, precautions would be necessary according to the interviewee's judgment. On the other hand, the interviewee expressed that the open sharing of knowledge

[3] However, the interviewee experienced within other projects that one specificity of the working environment in a transnational firm such as the partner MNE was that employees often rotate within the firm and that some teams, although being located in the USA, include people from Asia or elsewhere. This then sometimes increases communication problems, particularly in telephone communication. In other projects with Asian partners, the focal firm often seeks to use richer communication media. Furthermore, these partnerships are regularly accompanied by intercultural training courses in the specific culture of the partner. However, this potential communication impedance was not present in the case co-operation project with the partner team being entirely composed of native Americans.

generally necessitates time and trust. At the beginning, one hardly reveals everything but is naturally reserved concerning the kind and amount of knowledge shared with the partner.

In regard to the competencies pooled under this partnership, both partners – and particularly the people in team – had specialised expertise in different domains of the disease model. The pharmaceutical MNE is an expert in certain indication fields and conducts research in the discovery of new targets for novel treatments. The focal biotechnology firm by contrast disposes of the knowledge and technology to generate therapeutic proteins which bind at the specific target sites. These highly complementary skills are however based on similar basic bodies of knowledge in the fields of microbiology and biochemistry. The teams on both sides were composed of biologists, immunologists and technical assistants. This shared basic understanding of key constituents and mechanisms as well as a shared technical language eased the collaboration according to the interviewee. Nonetheless, the interviewee experienced that – despite this overlap in basic knowledge, which is generally present in this type of agreement – it is nonetheless difficult for the respective partner to comprehend the focal firm's specialised knowledge and competencies. In the words of the interviewee:

> *'What is definitely difficult and over and over again difficult within co-operation: to teach the partner our technology. That the partner understands what we do, that we are experts in this field, and that we do everything to reach the goals ... This kind of discussion we are facing permanently. And then you realise: If you enter into collaboration with a partner once, it is difficult; the second time, it becomes easier, then he [the partner] realises: "Ok, they are competent, they delivered last time, and what they did was good". Thus, also here you notice the increase in trust over time.'*

In this type of co-operation project, the partners rely on a division of invention labour, looking for partners who best complement the own knowledge and capability base. However, this separation of knowledge and skills still necessitates an understanding and comprehension of the partner's expertise in order to evaluate the partner's (potential) contribution, to understand how it fits the own needs and to be able to combine and integrate the distinct knowledge bases. Each partner has his specific area of expertise and the other partner needs to rely on the other's expressed capabilities, not being able to comprehend, evaluate or reproduce everything in detail. According to the interviewee, the appreciation of the other's capabilities and the faith in his competencies necessitates time and high levels of investments from the partners. Provisions are necessary to support this process, which were found in the design of the agreement as well as the implementation of explicit mechanisms to converge the knowledge of the respective sub-teams to some extent.

Specifically, this process is supported through the broad framework contract between the firms, offering stability to both partners and higher levels of trust at the relational level. Through this agreement, the partners demonstrated commitment and signaled mutual interest in the success of the joint projects. However, as this specific case project was among the first ones between the partners, it carried some of the burden of establishing relational proximity and trust among the partners. Furthermore, given the global spread of the partner, the focal firm is constantly confronted with changing teams as project partners. These are located in different countries and display different cultures, patterns of routinised behaviour, their own ways of communication, as well as their idiosyncratic specialised knowledge areas and capabilities.

Operationally, a co-operation project under this broad agreement starts with the identification of a new disease target by the pharmaceutical partner. Based on this novel target, the MNE approaches the focal biotechnology firm with a catalogue of requirements which the desired compound should fulfill. This was also the procedure in the case co-operation project when the pharmaceutical firm approached the focal firm with an identified target structure commissioning it to tailor a set of compounds. The biotechnology firm then takes over the lead to design an appropriate protein, drawing on its proprietary technology. Despite this division of expertise and labour, the incipient process was of a highly interactive nature with the constant integration of both partners' knowledge and skills. A period of very close interaction set in with often daily or even hourly interaction between the team members. A time line was devised to structure the work over the period of one year which was also subject to regular review processes and adaptations, if necessary. The co-ordination of the collaboration was achieved primarily via postal services to exchange test material, as well as electronic communication, first of all email, telephone and shared databases, in order to exchange data, discuss results and agree on further steps. This permanent interaction was affected at the level of the R&D

team members who were involved in the daily operation of the collaboration, but often didn't know each other personally.

> *'It was long a pure virtual team. ... Over several months, the people who did the research in the labs ... only had contact via email and telephone and some never became acquainted personally, or only after six months. This is the organisational challenge one has to face.'*

Besides these daily exchanges, face-to-face meetings were regularly scheduled. These face-to-face meetings took place four times a year at different sites, mostly the head offices of the MNE in Europe, thus significantly reducing the travel time for the focal firm.

> *'Our face-to-face meetings rotated between our site and [the partner's European headquarter], and the people from the US and other countries flew in.'*

The participants in these meetings were from the management level, including the heads of the laboratories, so-called 'lead scientists', who had an overview of the project and were also operationally involved in the research activities. Further R&D personnel did generally not participate in these meetings. Within the meetings, the current progress of the project was discussed, time lines checked and the next steps were discussed. Here, the sub-teams needed to demonstrate, explain and justify their work of the last period in-between the face-to-face meetings. The interviewee summarises that

> *'It works across [geographic] distance. However, it was extremely supportive that we saw each other regularly.'*

Furthermore, the regular review meetings face-to-face had an important additional function: it has been outlined that the co-operation built on complementary knowledge, which was however based on similar basic bodies of knowledge in biology and biochemistry. Nonetheless, despite a division of labour, frequent interaction and a close integration of the knowledge and capabilities of the members of the sub-teams was needed. Thus, an understanding of the partners' specialised knowledge and skills proved necessary to effect the co-operation. In order to converge the knowledge bases of the sub-teams to a requisite level which was necessary for communication and comprehension, a further measure was implemented. This measure consisted of joint presentations of the sub-teams of the interim results within the regular meetings. It is a usual habit to regularly present and discuss the state of the work; however, the joint preparation and presentation of the results was new. Usually,

> *'when we have a joint project, each partner presents his part. With [the specific partner], we arranged to make* one *presentation. That is, the team needed to do* one joint presentation. *Thus, the people from both sides needed to be able to communicate and to degree to such an extent that they could devise this joint presentation. ... This presentation was held in turns by someone from us and someone from [the partner]. ... [Hence,] a basic understanding needed to be present on both sides so that a joint presentation was possible. ... It was not possible to say, "this was his [the partner's] part of the work or this was his fault", but there was* one *team.'*

Thus, the instrument of jointly presenting the common endeavour served two purposes. First, the team members had to become familiar with the expertise as well as with the specific challenges the other part was faced with. This convergence in knowledge was supportive and also necessary in the course of the co-operation in order to share knowledge and co-ordinate the work. Second, a more subtle reason was that the sub-teams couldn't mutually blame each other for any delays, disappointments or failures. The instrument of jointly presenting the work proved to be a good tool to align interests, create a coherent team and achieve the degree of redundancy in knowledge needed to share knowledge. This was also perceived as having a positive impact on the motivation of the sub-teams to truly collaborate. According to the interviewee, this proceeding resulted in a more complex co-ordination process between the partners; however the interviewee underscored that the experienced benefits through this mutual *'teaching'* and the joint investments into *'becoming one team'* largely outweighed the additional costs.

Besides the co-ordination of the project and the alignment of knowledge and interests, the regular face-to-face meetings served as socialising events in order to reduce the relational distance between the partners and to establish mutual trust. This form of consciously engineering social contact was necessary as no spontaneous personal contact was likely due to the geographic separation of the partners.

Overall, the co-operation was perceived as highly successful and paved the way for the further collaboration between the focal biotechnology firm and the pharmaceutical MNE. A novel therapeutic compound was successfully designed which displayed the desired properties. This compound is now already in clinical trials and is rated as very promising. Hence, both goals were achieved. Next to the newly generated therapeutic compound, a number of papers and some patent filings resulted from the project. Hence, the inventive output was likewise highly satisfactory. Strategic and technological goals were insofar achieved as the partnership secured the focal firm's business model to provide customised proteins to external partners. The long-term agreement stabilises this line of business, with a partner with sound expertise and competences. Operationally, the project did not exceed the scheduled costs and time lines. In regard to the relational outcomes, the long-term contract which was initiated also by this initial success, is telling for the high level of relational proximity and trust and appreciation which was achieved in regard to both the partner's behaviour and competencies.

9.3.3 Case C

This case study is about a late-stage development project, which builds on the division of labour between a dedicated molecular diagnostics firm and a large multinational company active in the fields of pharmaceutical and diagnostic products. Compared to the other cases, this co-operation project is located much more at the back-end of the R&D process (development, market introduction) with the aim to commercially exploit the firm's knowledge and capabilities. From the perspective of the focal firm, access to resources and synergies between the firms weigh higher than learning from the partner.

Corporate Profile

The focal firm was founded at the end of the 1990s in the midst of the German biotechnology rise. At the end of 2008, the firm employed close to a hundred people, which worked at the two sites in Germany and the USA. The firm was an early entrepreneur in the field of molecular diagnostics and personalised medicine, which builds on the possibilities provided by molecular biology to fundamentally understand central disease mechanisms, detect diseases early on as well as develop tailored treatments. The focal firm aimed to exploit this potential as a molecular diagnostics firm, focusing on the development and commercialisation of in vitro diagnostics.

The firm pursues a hybrid business model as a product company as well as technology provider to other organisations. This way, the firm can generate revenues to finance its own projects and pursue its strategic aspiration to become a fully integrated molecular diagnostics company. Its prime business activity centers on research and development based on its proprietary technology. The company recently entered into its commercial phase.

General Co-operation Approach and Geographic Reach

Correspondingly, the firm's business model is inherently partner-based. The firm is actively looking for development and commercialisation partners for its biomarkers and diagnostic tests. This business model comprises two different types of agreements. In the first type of agreement, the firm offers biomarker discovery and outlicensing as a service for primarily industrial partners. These biomarkers are used in the drug discovery process or as commercial diagnostic products. The transition to the second type of agreement is fluid as in some cases the customers extend the license agreement to include joint development steps, such as the joint development of in vitro diagnostics for commercial purposes. The transition from one type to the other is accompanied by increasing levels of interaction among and integration of the partners. A division of invention labour and the need for complementary resources, as well as the joint realisation of synergies drive these co-operation agreements. Furthermore, the focal firm aims to establish its core technology as an industry standard.

Besides, the firm is involved in a network of university relationships, which range from informal interaction to joint R&D activities. These are motivated by the desire to *'try something out'*, learn and keep up with or adopt new scientific developments.

Targeting primarily large multinational firms with its partnering model, who dispose of the capacities to develop drugs and diagnostic products and use as well as introduce respective test systems on international markets, the firm's network of partners is by and large global. Also in regard to its university partnerships, quality counts more than geographic proximity according to the interviewee. However, the latter are frequently first sought in geographic vicinity, provided an adequate partner exists. The main reason for this different approach is found in differences between early stage research or exploration, such as first feasibility studies, and late stage development, or exploitation, projects.

> *'At the back end [of R&D], when it is about technology development, geographic proximity doesn't play a role any more. ... Research, particularly this first feasibility phase – one tries something out – there we don't want too high investments; in this phase, we also don't have too much money.'*

In research, concepts are often not yet proved and the results are highly unsure and unpredictable. Hence, less investments are initially sought which also implies the quest to prefer partners in geographic vicinity. With a project coming closer to its commercial realisation, it rises in value. Accordingly, higher resources are committed and a partner is sought who has the resources and capabilities to advance and commercialise the product. Here, processes are structured, the results become more predictable and less risky and geographic proximity becomes less important according to the interviewee.

Case Co-operation Project

In mid-2000, the focal molecular diagnostics firm entered into a co-operation project with a division of a large multinational pharmaceutical and diagnostics company, which is located in the eastern part of the USA. Within this co-operation, the MNE in-licensed a biomarker which was developed by the focal firm for the diagnosis of a specific disease. However, the agreement went beyond a pure licensing agreement to include the joint development of a diagnostic test system, which was tailored to be run on the partner firm's existing technological platform. The contractual goals of the co-operation agreement included the following:

- development of a diagnostic test which is compatible with the MNE's existing technology base (scored 5);
- introduction of the diagnostic test in Europe (scored 5); followed by the subsequent

- approval and introduction of the test in the USA (scored 4).

The prime motivation for the co-operation project was to join the distinct, complementary capabilities and resources of the focal firm and the multinational partner in the field of diagnostic tests, the combination of which was expected to yield important synergies. Furthermore, the partner disposed of the resources and capacities to launch the test internationally. This was supposed to constitute an important step on the focal firm's way to become an integrated molecular diagnostics company. Besides, the focal firm expected to further increase its global reputation and standing through this co-operation with a leading multinational diagnostics company.

As this project was qualified as a late-stage development project which built on a clear division of labour, the contributions of the partners could be explicitly specified and the output was quite predictable. Contractually, all ownership rights between the firms could be devised clearly and fixed formally. The focal firm non-exclusively out-licensed the marker to the partner. With successful development of a respective test kit and its market introduction, the focal firm would further be rewarded a milestone payment and would have a share in any later product sales. Building on this contract, the conditions were transparent for the partners.

Operationally, the division of labour between the partners was backed by a clear working plan, including time lines and mutual contributions. A project team spanning the two firms was composed which comprised a total number of fifteen people with varying compositions over time depending on the project's stage and the distribution of the workload between the partners. Next to scientists and technical personnel, this comprised a formal co-operation steering committee to supervise and ensure the progress of the project. This committee comprised six people, with three members from each firm being notably appointed.

In the first phase, which concerned the development of the test system on the existing platform from the partner, most of the development work was done by the focal molecular diagnostics firm. Here, the main technical challenge was to establish a technical fit and to integrate the new test system on the pre-existing platform. After realisation, a prototype was handed over to the MNE which finalised the development and scale-up in order to make the test available in larger numbers. The technology transfer consisted of the transfer of the prototype, which was accompanied by a written manual containing technical instructions to enable the partner to run the system independently. This kind of technology transfer was suggested to have eased the transfer as

> *'they [the partner] have something portable now, a tangible technology transfer, no theoretical technology transfer.'*

However, despite this strong division of labour, particularly the first phase of prototype development was a highly interactive activity which demanded the integration of different bodies of expertise within as well as between the companies. Thus, frequent interaction between the partners was necessary, which had to be mastered across a kilometric distance of slightly more than 7,000 kilometers, eleven hours travel time and a time difference of seven hours.

The prime media for communication were daily email exchanges. These daily exchanges took place between the scientists and technical staff of the sub-teams in order to exchange data, interpret and discuss the ongoing results. This process was closely supervised by the co-operation steering committee, which was informed about all conversations and which was formally authorised to take decisions. The committee met in a bimonthly rhythm in person in order to formally update each other, check time lines and the attainment of milestones, and decide upon the next steps. It was here that all important decisions were made and formally fixed in the form of minutes. Next to frequent flights to the U.S. site of the partner for face-to-face meetings, the exchange of the board members was supported by videoconferencing tools.

Besides monitoring the project's progress, these meetings also served to establish a requisite level of relational proximity between the partners. Social events which exceeded business affairs supported the creation of trust within the team. Overall, geographic distance was not perceived as a prime burden within the collaboration. Permanent geographic proximity could be substituted with virtual proximity as well as temporary physical proximity.

The smooth running of the co-operation project was further supported by the specific constellation of the partners in regard to comparable cultures (nationally, organisationally), compatible organisational structures and overlapping knowledge bases as is outlined below.

Institutionally, the partners were perceived as highly similar; however, different enough to be aware of and sensitised to existing differences between the partners:

> *'British and Americans always think that they understand each other; however, they always talk at cross purposes, because they don't realise it, because they seemingly talk the same language, but display enormous cultural differences. ... Between Germans and Americans one has the awareness "this could be due to language". Thus, one tends to be somewhat more careful and this is why it generally works better. Misunderstandings are fewer, because one is conscious about linguistic and cultural differences. One handles them in a more purposive way.'*

Furthermore, the focal molecular diagnostics firm – being a transatlantic firm itself – is used to interact with Americans.

> *'It is a little bit difficult to judge how big the challenge really is, as we are a transatlantic firm. That is to say, for us, the perception of these challenges is not too large. They are present, there are also misunderstandings, but nothing, which couldn't be handled. I can't affirm that our daily business was affected in any way [through cultural and language differences].'*

What further supported the collaboration according to the interviewee was the fact that the firms resembled each other in regard to their structure and operations. First, this was rooted in the nature of the partners' business. Both partners were active in the same field: diagnostics. In this field, operational sequences are highly standardised and subject to quality management standards. This is a specific of the partners' business which distinguishes it from other biotechnology businesses. Further,

> *'maybe research works differently, but by the time development starts, marketing and so on, you don't have so many degrees of freedom.'*

Second, the partner constellation displayed one more specific, which eased the co-operation, particular in regard to the comparability of the partners' mindsets and cultures:

'The molecular diagnostics unit of [our partner] is actually an acquired molecular diagnostics company. One notices this still today. That is, the differences have not been too large, because the history of these people is 90% comparable to ours. ... They are a group which used to work very autonomously and presumably still does to some extent. Thus, it [the differences in size and structure between the focal firm and the MNE] doesn't stand out. If this was with [another large MNE], for example, things would be different, because they had another history.'

Similar mindsets and approaches as well as a mutual understanding for the structure, organisation and challenges of the other, significantly eased the process of collaboration according to the interviewee. Moreover, a comparable structure was consciously created through the implementation of a formal governance structure in the form of the joint co-operation steering committee. This supported the alignment of interests, priorities and schedules.

However, this organisational proximity came at higher levels of strategic proximity between the partners. First, the partners agreed on a non-exclusive licensing deal of the biomarker. This gave the focal firm considerable degrees if freedom to use the biomarker for other purposes as well as in other partner constellations which might include a co-operation with direct competitors of the partner. This was initially no comfortable situation for the partner. Second, the partners were active in the same market for molecular diagnostics. While this was at the center of the focal firm's business model, from the point of view of the partner, the co-operation served to strengthen and expand its expertise in molecular diagnostics. Prior to this co-operation, its diagnostic portfolio was mainly based on more traditional diagnostic techniques. Hence, through this co-operation, the partners converged in their technology base, market portfolios, as well as strategic aspirations. However, from the point of view of the focal firm, this convergence was, for the time being, not necessarily disadvantageous for the firm, as well as the overall field of molecular diagnostics. As the market for molecular diagnostics is still nascent, the strengthening of molecular diagnostics within the partner's R&D and product portfolio was perceived as a chance for the broader acceptance and expansion of molecular diagnostic tests within the multinational partner as well as beyond.

> *'Hence, we see this very relaxed. The market is huge. Yet, it has to happen.'*

For this reason, the focal firm is also willing to collaborate with other competitors from the diagnostics scene, simply to raise the awareness, acceptance and future spread of molecular diagnostic tests. Furthermore, this potential competitive threat posed a greater hurdle for the marketing and sales units than for the R&D departments which were closer at the technical realisation of the project. Although *'one draws a line, but agrees on this line'*, the motivation within the team to share knowledge remained high, which was certainly a result of the general attitude toward the field.

Corresponding to this high degree of similarity in organisational terms and strategic positions, the partners also resembled each other in regard to the technological dimension. Although both partners had distinct capabilities in regard to their main strategic advantage, they had overlapping expertise in regard to the development of diagnostic test systems. Moreover, the development project drew on different disciplinary and functional competencies, such as biologists, laboratory technicians, physicians, statisticians and later also regulatory experts and marketing specialists. This was a challenging task as

> *'They all speak their own language. A statistician talks differently from a regulatory expert and so on.'*

Smooth communication between and integration of these different disciplines and functions across organisational boundaries was possible as each discipline and function was present and mirrored in both firms. Thus, it was possible to match each discipline and function with a correspondent on the other side. The interviewee perceived this correspondence as important in order to assure efficient inter-organisational communication in this highly inter-disciplinary and also cross-functional team composition:

> *'Everyone has his correspondent on the other side. ... If there was nobody on the other side who understands this language, one is easily lost. ... It must be warranted that an adequate contact exists. ... I believe, this is an important point. From that moment when you don't understand the language of the other in technical*

> *terms, you have a problem. … Most generally, you need someone who somehow understands the language [of the other].'*

It has been outlined that, despite a strong division of labour, intensive interaction between and integration of the partners took place. Hence, this congruency in expertise and functions was important to support technical understanding, particularly at geographic distance. From the focal firm's perspective, this was a purposeful act of matching competencies with the partner:

> *'There is indeed – and this is really a formal process – at the beginning of each project we look how to match. And this is kept throughout the collaboration. … That one layer on one side communicates with all layers on the other side, more or less undirected, this is not possible. … Also the technical assistants simply give each other a call, they also know each other personally meanwhile.'*

According to the interviewee, a structure of directed communication channels between people of similar backgrounds and positions, backed by personal acquaintance, supported communication; particularly across geographic distance.

This directed communication was also warranted through the joint co-operation steering committee where people of equal authority come together to take all decisions. Thus, the matching process not only took place in regard to functions and disciplines, but also in respect to hierarchical echelons. This proceeding secured mutual respect and equal power of decision of those who interacted. The matching of hierarchical echelons further represented a congruent escalation ladder in the case of conflict between the partners.

> *'Such a product development process is quite complex. It is extremely important that the same technical language is spoken. Yet, it is likewise extremely important that one keeps open channels for difficult times.'*

The interviewee underscored the important role of the co-operation steering committee, which was informed at all stages and formally authorised to take decisions.

Taken together, this high level of proximity in all dimensions – except for the geographic dimension – backed by clear governance structures, pre-defined inter-organisational routines, congruency in competencies and hierarchies and directed communication channels guaranteed a highly streamlined collaboration which was also confirmed by the results. The test was successfully developed and introduced into the market. This achievement marked an important step in the focal firm's business history. Through this deal, the firm came closer to its goal to become a fully integrated diagnostics company. Thus, the strategic, operational, as well as personal goals were all reached and in some cases the results even exceeded the focal firm's initial expectations according to the interviewee. Although not explicitly intended, also learning effects were realised, which occurred

> *'less so in obvious things, but in details. ... I believe, it was in these small things that it was immensely fruitful for both sides. Within technical collaboration some ruses, also market perceptions, which we saw differently from them.'*

From the point of view of the interviewee, the co-operation project is perceived to have led in a long-term relationship between the partners, which might also be a stepping stone for future collaborations with other renown partners in the future.

9.4 Case Analysis

While the presentation of the cases in the previous section was of a descriptive nature, the following sections are mainly analytical; i.e., the three presented case studies are analysed and discussed. The focus is on how management responded to the challenges by organising proximity; paying particular attention to any differences in respect to the respective invention stage and learning rationale.

In a first step, each case is be summarised briefly and the main insights are highlighted (section 9.4.1). Subsequently, the cases are compared in regard to the similarities and differences they display (section 9.4.2).

9.4.1 Within-Case Analysis

In the following, each of the case co-operation projects is summarised and analysed one by one. At the end of each case analysis, the main characteristics and insights are highlighted.

Case A represents a case co-operation project in which a firm engaged in an early stage research project with a European academic partner in order to learn about a new technological approach which might complement and extend the firm's current technological base. Correspondingly, the firm aimed to absorb the knowledge and skills in order to eventually adopt the new technology into its existing technological portfolio. The co-operation project was marked by high levels of uncertainty as the technology was still in a nascent stage and the proof of validity lacking. Thus, initially lower investments were sought with the option to adopt the technology in case of positive evaluation. This uncertainty was fueled by a low level of competence of the focal firm in the partner's specialised, emerging area of expertise prior to the co-operation project. While this rendered the co-operation project particularly complementary and attractive for the focal firm, both newness and lack of knowledge made the evaluation of the technology and its eventual contribution complicated and increased the risks. However, uncertainty in regard to the partner's competences and behaviour were mediated through prior relational ties with the partner. Nonetheless, the partner's goals and organisation differed fundamentally from the focal firm, which was perceived to be critical for the success of the co-operation project.

From the perspective of the focal firm, a close integration of the partner, backed by investments in learning and the alignment of processes were important measures. A recursive process started where material was exchanged in one direction and data from experiments in the other. This data was then jointly evaluated, discussed, compared with previous data and new requirements were formulated which spurred another loop in the process. As the knowledge was rather new to the firm, it engaged in a learning process to understand the principles of the other's specialty and the way of codifying results. Next to the general aspiration to learn about the partner's scientific field and his specific technology, this was a necessary step in order to be able to communicate and discuss the data across geographic distance. Particularly, communication between the sub-teams was primarily effected through electronic means, foremost email and telephone. Besides, learning-by-observing and learning-by-doing were important steps to comprehend and assimilate the knowledge of the partner. This was enabled through the temporary secondment of one employee to the partner. Although this was a chance position, it proved important to assimilate the knowledge and support communication and co-ordination across sites. It helped to establish trust between the partners and secured the alignment and continuity of the process. Besides, regular meetings between the sub-teams to co-ordinate and align the work took place quarterly. Thus, geographic distance was bridged through virtual proximity, a shared format of exchange of codified data, as well as regularly scheduled face-to-face meetings. Essentially, this process was supported through the secondment of one employee who worked on site with the partner . The co-operation project was fixed formally in a contract, which was however open to be adapted, amended or extended according to the future outcomes of the project. Table 9.1 provides a summary of the case study.

Table 9.1: Case Summary: Case A

Task characteristics:	
-	front-end research, technology scouting $\Rightarrow$ validity test
-	risky, task uncertainty $\Rightarrow$ results not fully predictable
-	lower investment with as yet unproven value
-	learning about an emerging scientific field and a specific technology as explicit goal
Relational characteristics:	
-	geographic distance $\searrow$, institutional distance $\downarrow$, organisational distance $\uparrow$, strategic distance $\uparrow$, technological distance $\nearrow$, relational distance $\rightarrow$
Measures:	
-	contractually fixed, but open for adaptations
-	investments in learning of the other's language and codes
-	close integration, daily email and telephone (virtual proximity), regular face-to-face meetings (quarterly)
-	secondment of staff as an important enabler for day-to-day interaction as well as learning from the partner; which also proved beneficial in other respects, such as to establish relational (trust) and organisational proximity (alignment of timelines)

$\uparrow$ = high, $\nearrow$ = rather high, $\rightarrow$ = medium, $\searrow$ = rather low, $\downarrow$ = low

Case B is a prototypic case of a joint research and early stage development project which is based on a division of work between a biotechnology firm and a large pharmaceutical MNE. In this case, the focal firm possessed a proprietary, validated technology, which could support the research activities of the partner, a US subsidiary of a large European pharmaceutical firm. Access to complementary resources was the prime rationale for inter-organisational co-operation and no competitive out-learning was feared. As the technology had proved valid and reliable in other partnerships and the firm's internal portfolio of drug candidates, the level of uncertainty was relatively low and the investments on both sides were considerably higher. The partners' knowledge bases were perceived as close; though complementary in their specialised expertise. This overlap was seen as supportive for the co-operation; however teaching of the partner was perceived as paramount due to the partner's unfamiliarity with the specific possibilities and limits of the technology. Besides, high degrees of similarities between the partners in regard to culture, both nationally as well as organisationally, and comparable work organisations and routines, despite considerable differences in firm size, were perceived as very supportive for the project. The interviewee underscored the high degree of projectification in R&D which helped the partners to quickly familiarise with the work organisation and dynamics of each other. In regard to meta-structures, however, differences existed and incompatibilities, particularly in regard to time horizons and schedules, eventually led to irritations and needed to be addressed in the course of the co-operation project. Relationally, the partners had no prior contact, but were both widely well-known companies in their respective fields, which mediated the perceived level of relational risks.

A co-operation team staffed with employees from both partners was formed for the project. Despite the division of labour, the incipient collaboration process was described as very close and intense with the constant integration of the partners' knowledge and skills and the need for a timely co-ordination of the tasks. The process proceeded in loops between the partners where compounds were developed and exchanged, their characteristics discussed and new features defined. For this process to function, the firm underscored the need to invest in the teaching of the partner, close personal relationships, as well as the alignment of the schedules of the partners. Being experienced in inter-organisational projects, the partners implemented team building measures from the start, including regular scheduled face-to-face meetings which were accompanied by social events to support personal bonding among the sub-teams. As team-building and teaching in the basics of the technology to establish a shared comprehension and shared expectations were perceived as important, the lead scientists were requested to regularly jointly present and defend their work in front of a steering committee. By turns, one representative from each sub-team had to present the state of the entire project. This measure proved important to induce a requisite level of learning on both sides and avoid buck-passing between the sub-teams. In between these quarterly meetings, communication was affected through electronic media, which was supported through the investments in mutual teaching and personal acquaintance. Besides, frictions occurred in the alignment of the overall work plans. Being operated in a number of different projects, each project had to be newly scheduled and prioritised. From the perspective of the focal firm, the remaining contractual leeway resulted in repeated bargains and inhibited dispatching and future work projections. Through continuous communication, it aimed to achieve acceptance of its needs and respect toward the other was learned during the course of the partnership. Besides, congruent structures in the form of a dedicated alliance management unit on both sides were perceived as important functions to have a contact point on an equal decision level which was able to timely settle eventually arising conflicts.

Further, case B is particularly interesting in respect to the relational dimension. The agreement was operated in a number of distinct projects. Changing team compositions contributed novel approaches; however, at the expense of the full exploitation of relational proximity which could be established within a long-term agreement. A summary of case B is provided in table 9.2.

Case C is a development project between a German molecular diagnostics firm and a multinational pharmaceutical and diagnostics firm based in the US, which is primarily geared at the exploitation of the focal firm's knowledge and skills. Building on a new marker which was identified by the focal firm and in-licensed by the partner, the joint development of a respective diagnostic test and its integration into the partner's existing platform were core to the co-operation project. The realisation of this technical fit was described as technically tricky but not disruptive with the outcome being predictable from the onset. Being active in the similar field, i.e., molecular diagnostics, the partners were perceived to have comparable knowledge bases. Thus, the basic scientific and technical understanding of the mechanisms as well as the specifics of molecular diagnostics was given on both sides. As this project was close to market introduction, a broader array of specialties was integrated within the project; comprising physicians, statisticians, regulatory and marketing experts on both sides. Hence, the sub-teams were highly interdisciplinary and functionally

Table 9.2: Case Summary: Case B

Task characteristics:
- applied research, early development
- medium level of uncertainty, technology past proof of validity
- no learning intent, enduring division of labour
- considerably higher investment
Relational characteristics:
- geographic distance ↑, institutional distance ↘, organisational distance →, strategic distance ↗, technological distance →, relational distance ↗
Measures:
- contractually fixed in regard to contributions and outcome sharing; however leeway for organisational implementation (mirco-bargains)
- close integration, daily electronic communication, regular face-to-face meetings (quarterly)
- mutual teaching, regular reporting and team building measures through joint presentation and social events
- structural alignment through alliance management unit (‘helicopter view’)

↑ = high, ↗ = rather high, → = medium, ↘ = rather low, ↓ = low

diverse, but resembled each other across the partner organisations. While increasing the strategic proximity of the partners, this proximity in knowledge and competence was perceived as supportive to jointly effect the project, as well as advance the nascent field of molecular diagnostics. In regard to institutional and organisational differences, the partners were perceived as comparable. Institutionally, the focal firm – itself a transatlantic firm – was experienced in doing business with US partners. Besides, the partner unit – a former independent small diagnostics company – was perceived to have retained its entrepreneurial spirit, thus resembling the focal firm.

From the perspective of the focal firm, the implementation of a streamlined, synchronised process was perceived as important in order to attain the goals of the project and timely reach market introduction. The project was of high value to the focal firm as it was supposed to mark an important step in its overall development. A joint project team was set up, which comprised scientists, technical staff and other specialties according to the stage of the co-operation project. Moreover, a formal co-operation steering committee was implemented which closely supervised the project and bundled the power of decision. The team was internally highly differentiated in disciplines and functions. However, the sub-teams displayed a similar internal composition where each discipline and function was mirrored in the sub-team of the partner. Thus, the challenges posed by high degrees of inter-disciplinarity and cross-functionality were kept within the confines of the firms and communication between the firms was directed and took place among peers (functionally, disciplinary and also hierarchically). This congruency enabled a pattern of directed communication among peers which proved helpful to streamline the process and prevent conflict. The interviewee underscored this 'matching process' as a very important measure, which was even more important as the partners had to span a large geographic distance. Across the organisations and functions, the co-operation steering committee functioned as a monitoring body, mediator and decision-maker. Thus, a temporary shared governance structure was implemented for the time of the project. In the first phase of prototype development, most of the development work was done by the focal firm on the bases of the partner's technological platform. Nonetheless, the process was integrative and interactive and the partner was constantly involved to contribute his expertise, discuss possibilities and limits and desired product specifications. Routine day-to-day communication took place informally among the scientists and technical staff but was closely supervised by the steering committee. Communication was primarily affected via email and telephone, while the steering committee met frequently in person and in a virtual space offered by videoconferencing. The final transfer of the result was then based on a hand-over of the technical solution in the form of a prototype and a manual. Thus, a 'tangible technology transfer' took place which supported the transfer of knowledge to the partner. A summary of case C is provided in table 9.3.

Table 9.3: Case Summary: Case C

Task characteristics:	
·	(late-stage) development
-	predictable results, low levels of technological uncertainty
-	high investment, high value at stake
-	no learning intent
Relational characteristics:	
-	geographic distance $\uparrow$ institutional distance $\downarrow$, organisational distance $\rightarrow$, strategic distance $\nearrow$, technological distance $\searrow$, relational distance $\uparrow$
Measures:	
-	contractually fix (low leeway)
-	highly structured and formalised process (milestones, specifications)
-	shared temporary governance body: implementation of joint co-operation steering committee as central decision body and escalation channel
-	disciplinary, functional and hierarchical matching process across organisations
-	close integration, directed lines of communication; virtual and informal day-to-day exchanges between scientific and technical personnel; regular face-to-face meetings of co-operation steering committee (bimonthly)

$\uparrow$ = high, $\nearrow$ = rather high, $\rightarrow$ = medium, $\searrow$ = rather low, $\downarrow$ = low

9.4.2 Cross-Case Analysis

This section presents a comparative analysis of the case co-operation projects in respect to their reach and effects of distance in different dimensions and the partners' organisational responses.

To begin with, the three case projects have been consciously selected based on their belonging to different categories in respect to their invention stage as well as their learning rationale. Thus, they differ by design in regard to these variables. While case A is characterised as early research, case B is classified as applied research and case C as development. Correspondingly, the projects are positioned on a continuum from exploration to exploitation of knowledge and expertise. Regarding the second selection criteria, case A is characterised by the explicit intent to learn from the partner while cases B and C relied on a division labour. Thus, there is also a continuous grading between the three projects in this second selection dimension (see figure 9.1).

The projects also differ in regard to the extent of distance they incurred in different dimensions. Whereas the degree of institutional distance is perceived as low in all case projects – also due to the internationality of the firms themselves – they differ considerably in regard to the geographic distance separating the partners. While case A is a European project, cases B and C span across the Atlantic and the partners are separated by a metrical distance of more than 6,000 kilometres. However, these large geographic distances were not perceived as a hindrance for successful co-operation. Moreover, the interviewee of case A perceived this relative geographic proximity as supportive, but not necessary.[4]

Furthermore, the projects differ in the degree of organisational distance between the partners. In case A, a university group was sought as co-operation partner which was perceived as different in regard to all dimensions of organisational distance; i.e., its aspirations and self-perception, structure, routines and culture. To bridge these organisational incompatibilities was perceived as a major challenge within the co-operation project. In the other two case co-operation projects, the partners were large multinational firms. Yet, they were perceived as closer in organisational terms. Case B underscored comparable organisational units in the form of projects within both firms to support inter-organisational co-operation, but considered the alignment of structural incompatibilities at a higher organisational level, particularly in regard to schedules and time lines, as a challenge. Case C indicated no significant organisational differences, particularly due to the fact that the focal firm had already reached a considerable size which led to a functional differentiation similar or at least compatible to the large multinational partner. The interviewee of case C further underscored the existence of a comparable mindset and spirit of the partner. In this case, the partner division – a former independent molecular diagnostics firm – was perceived to have retained its entrepreneurial spirit despite its integration into a larger enterprise.

Considerable differences between the cases became also evident in regard to the technological dimension. Case A underscored the relatively high distance in knowledge and techniques between itself, a cell specialist, and the partner, a specialist in proteomics and systems biology. This level of distance was rated as unusually high for external co-operation and was perceived as a challenge for both partners.[5]

[4] It needs to be considered that the partners of case A were also separated by a geographic distance of around 400 kilometres, which likewise prevents chance meetings or day-to-day encounters.

[5] The interviewee reported that the firm generally aims to retain disciplinary variety within the firm and seeks external partners that are rather close in their prime knowledge base. This

Case B underscored a high degree of overlap in the basic bodies of knowledge of the partners, but acknowledged differences in regard to the specialised knowledge and competences. According to the interviewee, this lack of comprehension of their specialised expertise constituted a challenge within the co-operation that had to be addressed. The interviewee of case C observed no significant differences in either the basic or the specialised bodies of knowledge and expertise of the partners. Both were considered to be specialists in the field of molecular diagnostics; although the partner was currently unlocking this field, being traditionally strong in conventional diagnostics techniques. Besides, an overlap in other disciplines and functions, which needed to be integrated into the co-operation project, was existent and highly supportive for the project.[6]

In regard to the strategic dimension, cases A and B ranked their partners as distant, while case C acknowledged a rather high degree of proximity between the partners. However, the firm did not perceive this level of proximity as destructive, due to the overall dynamics of the field as well as the higher strategic agenda to forward the entire field of molecular diagnostics, its broad adoption and acceptance and set de facto standards.

Relationally, all three case co-operation projects were marked by rather high levels of distance. Nonetheless, case co-operation project A was initiated through a previous personal acquaintance of the partners. This prior link also called the attention of the focal firm to the eventual possibilities of proteomics and systems biology for its own technology and product portfolio. Besides, the firm underscored that this initial level of trust helped to create an open climate within the co-operation project. Cases B and C started from scratch. They built on a conscious search for partners that are long-established, well-known players in the field. Thus, the level of reputation made up for personal acquaintance, at least to some degree. However, in all three cases, no inter-organisational routines or shared languages and codes had been

strategy was pursued in the face of experienced problems in interdisciplinary work, which are, according to the interviewee, easier solved internally than with external partners.

[6] The comparison between research and development projects in section 8.3.1 has revealed that collaborative research projects are in general characterised by higher levels of technological distance compared to collaborative development projects. This greater quest for variety or new knowledge is also found in the current cases.

established prior to the focal co-operation project.[7]

Based on these differences in invention stage, rationale and contexts, the incipient process and organisational mastery of the projects display some commonalities across the cases but also some marked differences.

First of all, a common characteristic of the three projects is their iterative and stepwise character. They were initiated by a specific scientific finding or technical need. The partners then combined their expertise in an iterative process of experiments, data evaluations and discussions, where they drew conclusions and repetitively defined and redefined requirements. Thus, the projects were proceeding in tight loops between the partners that needed to be closely coupled or synchronised across the sites. Besides, frequent questions arose spontaneously which needed to be settled between the partners. To master this process, three organisational domains had been addressed by the interviewees: governance, competence and relationship. However, the instruments which they designed in each of these domains differed.

First, the interviewees addressed the formal **governance** of the projects. Contractual arrangements were deliberately designed and implemented by the partners in all three cases, including a formal fixation of the goals and the contributions of the partners, as well as arrangements on the sharing of results. However, comparing the case projects, it stands out that the the degree of formalisation and thus the remaining leeway in the contracts differed between them. In line with their invention stage, the projects were characterised by different levels of uncertainty and outcome predictability. With the transition from early research to close to the market development, the level of uncertainty of the outcomes significantly decreased. At the same time, the worth of the project increased and so did the investments of the partners. Thus, the degree of fixation and the remaining leeway in the contracts mirrors the perceived need for flexibility and the possibility to predict the outcomes of the project. It also reflects the increasing value attached to the project (or the losses to be anticipated in the case of failure) as the projects moved from research to development.

In case A, the outcome of the project could not yet be envisaged at the outset

[7] Note that the statistical comparison in section 8.3.1 has revealed that research projects are generally more likely to be initiated through prior relational proximity compared to development projects.

of the project, the contract was open-ended, and mainly included the right to test the new technology and be a first mover in the case of successful proof of concept, as well as the joint publication of results. This contractual leeway was also accepted as the partner was not perceived as a competitor, but as a trusted partner due to the previous, informal acquaintance, backed by a high degree of institutional proximity of the partners. In cases B and C, the outcomes of the projects were much more predictable and the contractual arrangements included detailed provisions on ownership rights and compensation schemes of the partners. The underlying knowledge was protected through patents and both contracts built on licensing agreements between the partners, followed by performance-related milestone payments and arrangements on the sharing of revenues after market introduction of the products.

Thus, this increasing tightness in contractual regulation is also mirrored in the degree of formalisation of the co-operation process. Tight inter-organisational structures and routines – such as detailed work plans, time lines and milestones, sequences of meetings, communication lines and authorities, as well as escalation channels – are used to an increasing extent when the outcome as well as its value become seizable and the process can be structured and planned. Particularly the implementation of supervisory boards or steering committees is a measure which substitutes to some extent the possibilities for control and direction within firms.

In particular in case C, a highly formalised governance structure, including notably appointed authorities and communication lines and a tightly synchronised and supervised process were implemented. A temporary governance structure in the form of a co-operation steering committee was implemented to supervise the project's progress, monitor the attainment of milestones and bundle decision making. Also case B implemented a dedicated alliance management unit as a central authority and escalation channel. The contract was operated in a number of subsequent projects and their scheduling had to be negotiated during the co-operation agreement. This resulted in repeated bargains for which this formal authority proved necessary; particularly as the structural differences in the partners' organisations and divergence in schedules and time lines were anticipated to be a potential cause of conflict. In case A, no such formal structures were devised, which was in part due to the lower degree of investments sought as well as the structure of the university department, which was not as functionally differentiated as the firm, but centred on the professor who combined many functions in one person. However, the organisational distance with respect to goals, time lines, routines and culture was perceived as high, which was seen as critical for the success of the co-operation project. Thus, to circumvent monitoring and enforcement problems from a geographically distant position, the secondment of personnel proved to be an effective measure to secure the (constant) alignment of interests and the project's progress.

Second, the **competence** of the partners to share knowledge was a central issue across the cases. While variety in knowledge and skills was deliberately sought to leverage complementary resources or access promising emerging research areas, it also had to be mastered within the project. Depending on the level of technological or knowledge distance and the presence of a learning intent, different investments to establish a requisite level of proximity or (initial) convergence in knowledge between the partners needed to be incurred.

In case A, the interviewee emphasised the initially high level of technological or knowledge distance, which had to be reduced in order to be able to communicate and eventually adopt the methods from the partner. Within its partner's specialty, distinct ways of expressing and codifying knowledge through systems of symbols and standard protocols had been established. Coupled with the geographic separation of the partners, this had two consequences. First, in order to resort to electronic means for regular communication, data sharing and joint interpretation among the partners, the codes and basic relationships of the partner had to be learned. Second, the desire to eventually adopt the techniques needed an even closer integration, including on site observation and direct interaction with the partner. This was solved through the secondment of one scientist to the partner for the duration of the project.

Cases B and C built on a division of labour that corresponds to a strategy of learning with the partner. Nonetheless, the projects implied frequent, daily or even hourly, exchanges and a close integration of the partners' knowledge. In case B, the interviewee reported a high level of overlap in the basic bodies of knowledge of the partners, which facilitated the understanding of the elementary principles upon which the specialised knowledge of the partners built. However, the firm experienced that the comprehension of the specific technology proved difficult for the partner. Thus, teaching was underscored as an important process in order to enable the partner to understand the contribution and limits of the technology, communicate and interpret results and formulate further specifications. Also vice versa, the focal firm had to learn about the target structures identified by the partner. Mutual teaching and learning of the team members from both organisations was induced and incentivised through the measure of joint regular presentations, which were in turns held by members from each sub-team.

Also in case C, the competence of the team members to communicate was underscored. However, with both partners being active in molecular diagnostics, a requisite level of knowledge overlap – in both the basic and specialised bases of knowledge – was perceived as given. However, the teams not only comprised scientists of different disciplines, but also different functions, such as regulatory affairs and marketing. Directed communication between members of different disciplines and functions across organisational boundaries was perceived as necessary to achieve frictionless communication. Thus, a process of competence matching took place before the operational start of the co-operation project. Furthermore, the partners could discuss a real object as a tangible knowledge transfer instead of an intangible transfer of knowledge took place which was perceived to facilitate knowledge sharing.

Thus, the establishment of a requisite level of knowledge overlap, either through learning and teaching or through the conscious composition of teams and communication channels, proved necessary for the success of the co-operation projects. Across the cases, there was an initial investment stage to acquire a (rudimentary) understanding of the partner's knowledge and skills. These initial investments in knowledge convergence allowed for divergence and mutual specialisation during the operation of the project. However, the means to establish proximity differed between the cases according to the initial levels of technological/knowledge distance and the learning rationale.

Third, **relationship** building accompanied the other measures and the interviewees reported that trust in the partner, his behaviour and competences, was an important prerequisite for open knowledge sharing. In case A, key employees from the partners knew each other before the co-operation project, but the degree of relational proximity was loose and marked by infrequent, informal encounters. This contact was the ignition for the co-operation and also helped to trust in the so far unproven technique. Moreover, the permanent direct contact through the employee who was seconded to the partner helped to build a close relationship and strengthen initial levels of trust. The interviewee of case B underscored his ambition to create a cohesive team transcending the partner organisations, at various points underscoring his desire to create 'one team'. This was perceived as an important prerequisite to raise the commitment of the sub-teams and to avoid buck-passing. The joint presentations which were regularly scheduled served to establish this requisite level of bonding and cohesiveness of the sub-teams. Besides, cases B and C implemented socialising events which accompanied each formal face-to-face meeting. These events helped to increase the motivation and dedication of the sub-teams and at the same time supported the creation of redundant knowledge. As chance encounters or frequent face-to-face meetings were not possible with considerable degrees of geographic distance separating the partners, the firms had to consciously engineer these places for socialisation.

Across the cases, geographic distance between the partners was not perceived as crucial. For day-to-day communication, the partners resorted to email and telephone and thus the virtual space. Here, material and information circulated extensively across geographic distance. What proved to be more important was the ability of the partners to use these tools for communication which was contingent upon a requisite level of knowledge overlap. Besides, for more intensive exchanges and learning to take place, scheduled face-to-face meetings or the secondment of personnel were important measures. Likewise, relationship-building needs more extended, face-to-face, forms of interaction; which can however also be established through temporary visits or meetings.

To conclude, hypotheses 9 and 10 have suggested differences in the effects of distance with respect to differences in the invention stage and learning rationale. However, despite considerable differences in the challenges associated with both the respective invention stage and the learning rationale, no overriding differences in the effect of distance in different dimensions could be identified. Two possible exemptions are a higher (lower) quest for variety in knowledge within research (development). In development, it seems that firms avoid high levels of knowledge distance which reduces technical and relational risks. Besides, co-operative research projects more often build on previous relationships which is a function of both a higher likelihood to identify new approaches and also a way to reduce the risks inherent in research. In particular, trust in the partner, his behaviour and competencies, mediates the general higher risks associated with research.

Hypothesis 11 has suggested that there is room for managerial responses and that the achievement of the project's goals as well as its outcomes in respect to invention, strategy, efficiency, personal satisfaction and relationship building are mediated by the way, management achieves to establish a requisite level of proximity in all dimensions. This hypothesis is supported by the case analysis that provided detailed insight in the different organisational responses which the firms resorted to in order to bring the project to success. Moreover, the different instruments which have been described support hypotheses 12a and 12b, postulating different organisational responses in regard to different requirements associated with different invention stages and learning rationales.

9.5 Summary and Conclusions

In this chapter, three case studies have been described and analysed in detail. The aim has been to explore the process of inter-organisational co-operation, incorporate the time aspect and gain insights into management responses to achieve proximity within the team. Explicit attention has been paid to different contexts as well as different invention stages and learning rationales. These two intermediary variables have been discussed to define different challenges and to require different organisational responses. Accordingly, the selection of the cases has followed a systematic approach, based on a matrix spanned by the two dimensions invention stage and learning rationale.

The case description and subsequent discussion has shown that the case projects displayed differences as determined by the intermediary variables. In regard to the respective positions in the invention stage, differences became evident with respect to the level of (technical) uncertainty, the degree of outcome predictability, the possibilities to (contractually) formalise and structure the project and the value attached to the project. Besides, it turned out that the intention to learn from the partner demands a closer interaction with the partner to allow for learning-by-observation, imitation and training.

However, there are also considerable similarities between the cases. In particular, three central organisational domains have been addressed by the interviewees that serve to establish or substitute proximity in different dimensions: governance, competence and relationship (figure 9.2).

Governance comprises contractual and organisational measures. Contractual measures serve to minimise the firm's vulnerability to relational risks and potential

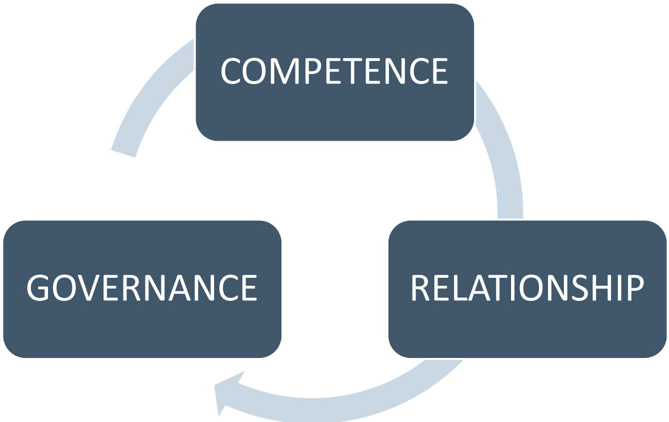

Figure 9.2: Organising Proximity: Organisational Domains

disagreements over goals, contributions as well as the sharing of the results; while organisational measures aim to structure the day-to-day operation of the project and avoid friction and conflict. Contractual measures typically include agreements upon goals, contributions, time lines and work plans, as well as ownership rights and confidentiality agreements. Organisational measures comprise the definition of compatible structures and authorities, such as steering committees, the establishment of inter-organisational routines and lines of communication, as well as the (notable) assignment of team members (table 9.4). Likewise, the implementation of a compatible ICT infrastructure is subsumed in this category. Together, these measures need to be constantly surveyed and aligned to the project's stage and requirements.

They serve to reduce the level of uncertainty, increase the alignment of goals and schedules and stabilise the co-operation, also in the case of conflict. These investments primarily respond to organisational differences, institutional, strategic and relational risks; however they also lay the fundament to establish proximity in knowledge.

Competence addresses the qualification of those involved to actually collaborate. Depending on the initial level of technological/knowledge distance, investments are needed to establish a basic level of comprehension of the field of the

Table 9.4: Organising Proximity: Organisational Measures

Governance
• Definition and alignment of goals • Formal agreement on the sharing of results, confidentiality agreements • Definition of contributions, work plans, timelines and milestones • Definition of compatible structures and authorities ('steering committees', escalation mechanisms); inter-organisational routines (communication lines) • (Notable) assignment of team members • Implementation of compatible ICT infrastructures • Constant monitoring and alignment/negotiation of goals, timelines and contributions
Competence
• Ex ante creation of knowledge redundancy through competence matching, integration of knowledge brokers • Ex post creation of knowledge redundancy through mutual teaching and learning, *joint* interpretation of data • Regular face-to-face visits, eventually secondment of personnel • Knowledge externalisation through codification (e.g., standardised protocols) and boundary objects (samples, prototypes) • Internal definition of revelation boundaries
Relationship
• Personal acquaintance of team members, socialising events • Regular meetings, secondment of personnel; creation of mulitplex ties • Demonstration of commitment (long-term vision of relationship) • Sensitivity in regard to differences in the partner (e.g., cultural, organisational, in expertise); in particular inter-cultural competence building (training, visits, secondment)

partner and the joint potential, to understand fundamental relationships and the limitations the partner is confronted with, as well as to become familiar with his codes; both in terms of technical language and ways of presenting data.[8] This does

[8] This organisational domain foremost addresses the *technical* competence, which proved to be an important success factor for inter-organisational co-operation in R&D (see section

not only increase the own absorptive capacity, but also the disseminative capacity to enable an appropriate judgment of the partner's information needs. Supportive measures are the conscious creation of redundancy through the assignment of team members, the integration of knowledge brokers, as well as early investments in learning and teaching. Frequent discussions and joint interpretation of data to comprehend the way the partner judges data, backed by mutual visits, personnel exchanges or secondment to learn directly from the partner are important direct means to bridge knowledge gaps. Moreover, investments in knowledge externalisation, such as standardised protocols, manuals or boundary objects (e.g., samples or prototypes), support knowledge sharing. Through these investments, team members are enabled to exploit the possibilities of the co-operation to their full potential.

The height of the investments depend on both, the initial overlap in knowledge as well as the learning rationale. In particular, learning from the partner necessitates higher investments in knowledge assimilation than a division of labour. However, considering the risk of losing strategic knowledge to the partner, a conscious weighing of how much to reveal of one's own knowledge is necessary: too much information can risk the own competitive advantage; too few information risks damaging the success of the project. A trade-off between what is necessary for the progress of the project and what should be kept within the confines of the firm is necessary.

These measures primarily address the effects of technological distance between the partners, which has been shown to be of central importance for the co-operation to succeed (see section 8.3.2). Besides, investments in competence and thus the basic understanding of the partner's knowledge base and skills support the evaluation of his behaviour and competence, which lowers relational risks. The decision on the amount of knowledge to be shared also hedges against strategic risks.

Relationship building has been identified as a third organisational domain. Analogous to the findings in section 8.3.2, this domain serves a rather indirect purpose, as it primarily raises the motivation to collaborate and strenthens the other dimen-

8.3.2). With increasing levels of institutional distance and lower levels of familiarity with distant cultures, also *inter-cultural* competence needs to be established. While the current investments in culturally distant countries are low, they are assumed to rise in the future and correspondingly will the importance of inter-cultural competence. Inter-cultural competence is here perceived as an important enabler that is subsumed under the domain of relationship building; however, it is supposed to indirectly influence the ability to share scientific and technical knowledge.

sions. The establishment of relational proximity serves to increase the level of trust and bonding among the team members. Personal acquaintance is the prime topic here, which is supported through measures such as socialising events which accompany and complement business meetings, the use of richer communication channels, visits, personnel exchanges or secondment. Also the demonstration of long-term commitment to the relationship and the signalling of its appreciation toward third parties helps to create trust and commitment. Besides, a requisite level of sensitivity toward the partner, in respect to cultural, knowledge and organisational differences needs to be established. Although the general tenor was that a shared scientific spirit and shared technical language and approaches in R&D can level out cultural differences, an increasing spread of knowledge generation activities to institutionally distant countries will necessitate investments in both depth and breadth of inter-cultural competence, which can be achieved through training courses, visits or secondment.

Governance and relationship are sometimes perceived as two complementary or substitutive domains, particularly when incomplete contracts prevail such as in co-operative R&D (Nooteboom, 2009). Thus, long-term relationships as well as the creation of multiplex and close ties increase mutual security, stability and a feeling of obligation to contribute. In this sense, relational proximity can partially substitute for formal contractual governance as well as a lack of competence to evaluate the partner's contribution in the absence of complete contracts. Besides, investments in relationship-building not only serve to build trust, but also to become acquainted with or develop a shared tongue which in turn supports competence-building and reduces misunderstandings. Thus, although this domain primarily addresses relational risks, it also supports the building of redundant knowledge which supports knowledge sharing.

The final investments in governance, competence and relationship and the design of measures need to be tailored according to requirements of the specific project. Different investments are needed in line with the positioning of the actors vis-à-vis each other in different dimensions of distance, the respective invention stage and learning rationale. Thus, the measures in table 9.4 represent a toolbox which needs to be tailored according to task and contextual specifics of a particular project.

10 Research and Practical Implications

While Chapter 8 analysed the impact of (initial levels of) distance in different dimensions, Chapter 9 turned to the opportunities to establish proximity within the project. This chapter fuses the key findings from both chapters (section 10.1) and derives conclusions thereof for theory (section 10.2) and practice (section 10.3).

10.1 Key Findings

To remain competitive in this science-based, highly dynamic business, dedicated biotechnology firms have to constantly invest in R&D and participate at the permanently shifting global science and technological frontier. As one means to achieve this, they frequently engage in co-operation with external partners of different kinds (universities, research organisations, small and large firms).

- The preferred form of inter-organisational co-operation in R&D are **projects**. These last between one and three years and offer a flexible, relatively low investment form of access to external resources for both research as well as development activities.

- As prime motivation to engage in inter-organisational projects, the firms seek access to **high quality** or **unique knowledge** and **skills** from external partners, in order to complement or expand their internal knowledge and skill base.

- Due to the high degree of specialisation within a global knowledge and technology market, valuable resources and skills are mostly not available in close geographic proximity, but spread across different regions and countries; impelling the firms to **combine the best of local resources and skills with global ones**.

These strategies are currently primarily TRIAD-centred, with most partners being located in Europe and the US. However, the interviewees expected international

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co-operation activities to increase in number and country scope in the future; particularly with the emergence of new biotechnology players from the BRIC states. Although many firms currently hesitate to invest in these countries, future investments are perceived as likely.

Centrally, the analysed co-operation projects are characterised by varied levels of success. To explain this variance, the analysis has drawn on the recent insight of a multiplicity of forms of distance or proximity which underpin and shape interactive learning and novelty generation. A framework of six dimensions – geographical, institutional, organisational, strategic, technological and relational – has been developed and applied. The empirical investigation has shown that a considerable share of the variance in success can be explained by the distinct benefits and challenges of reaching out to varying extents in different dimensions:

- In line with the predictions from innovation and learning theory, the combination of distant bodies of (scientific) knowledge and (technical) expertise – summarised as **technological distance** – yields the highest rewards, but also poses the greatest difficulties for inter-organisational co-operation; particularly when exceeding a threshold level which yields maximum benefits (inverted U-shaped relationship). In particular, an overlap in basic bodies of knowledge or the existence of a knowledge 'broker', are perceived as important for successful inter-organisational co-operation.

- **Institutional distance** – likewise related to varied knowledge and cognition – has proven to be beneficial up to a threshold level when the firms display liabilities of moving out of their experience zone (inverted U-shaped relationship). Interestingly, a shared scientific or epistemic culture has been perceived to create more commonalities than the differences that different national cultures bring about. However, with increasing levels of institutional – especially national cultural – distance, having to accommodate to different cultures, facing language problems with different levels of English proficiency and different styles of communication coupled with a generally higher perception of relational risks, eventually outweighs the initial benefits of institutional distance.

- While technological and institutional distance are directly related to the ability of the partners to share knowledge, **organisational** and **strategic dis-**

tance are primarily associated with motivational factors affecting the willingness of the partners to share knowledge. In deliberate processes of knowledge sharing, such as in inter-organisational R&D, these motivational factors are less strong predictors of the success of a project. While the effect of organisational distance varies, strategic proximity can even be beneficial to induce a stronger drive into the co-operation project as no partner wants to leave the field to a competitor.

- Against the canonical view, **geographic distance** per se does not exert a discernible impact on knowledge sharing in inter-organisational R&D. However, it exerts an important indirect impact: In the case of high degrees of technological and/or organisational distance, geographic distance turns into a liability, decreasing the overall exploitable potential of the relationship and increasing the likelihood of conflict between the partners. Thus, when the partners have to span high levels of technological (or knowledge) distance, geographic proximity is supportive, while geographic distance prevents the needed amount of face-to-face interaction. Similarly, (latent) friction due to organisational differences are more likely to come to the fore when the partners have less insight and control over each other with high levels of geographic distance.

- In this highly dynamic field, co-operation partners and network compositions change constantly. Thus, only a minority of ties stems from previous relationships. Although **relational proximity** has been suggested to play an indirect facilitating role due to prior levels of proximity in cognition and structures, as well as increased levels of trust, the full exploitation of these advantages is rarely possible. While previous ties can constitute a source of new ideas or a channel to information, highly specific resource needs are mostly addressed as initiators for inter-organisational co-operation which imply new search processes for new partners. Correspondingly, relational distance has been no strong predictor of the success of an inter-organisational co-operation project in the sample.

Together, the existence of a ‘global optimum’ of distance has been suggested that is defined by the simultaneous consideration of the different dimensions of distance and their effects, which deviates from the individual ones.

Finally, it has been demonstrated that a well-devised international co-operation project can overcome many of the liabilities of distance in different dimensions. Three organisational domains have been identified: competence, governance and relationship.

- In line with the empirical finding of a dominant impact of technological distance, a key managerial task to organise proximity within the project is **competence building** (teaching, learning), in order to enable the team members to integrate different bodies of knowledge.

- This needs to be backed by a supportive **governance structure** and **relationship-building** measures to yield a requisite level of security and trusted atmosphere within the project.

Co-operative R&D in biotechnology usually proceeds in close iterative loops of material and data exchanges, (joint) interpretations and definitions of next steps. To enable the team members to achieve this integration in a timely manner through competence building is of topical importance; in particular in temporary organisations such as projects. However, this can only be achieved on the basis of an appropriate governance structure which conveys security and structure, including contractual regulations, in particular on the distribution of ownership rights, temporary structures and concerted inter-organisational routines (e.g., lines of communication, hierarchy and escalation). As these governance structures are by definition incomplete and as knowledge sharing is a very personal and delicate activity, trust and thus a requisite level of relationship-building is an important precondition for successful co-operation in R&D.

Together, the investment in all three domains – competence, governance and relationship – vary with the actual partner constellation, the invention stage and the respective learning rationale.

- In particular, in research compared to development, a higher need for variety is sought; however, higher uncertainties prevail and lower investments are initially sought. By contrast, development tends to be less uncertain with higher values at stake. Trusted partners are sought which are closer in knowledge in order to lower the risks and increase mutual understanding.

- Similarly, while many projects pursue a strategy of learning *with* the partner, also learning *from* the partner is sometimes sought. While both forms of learning necessitate some level of knowledge overlap or (initial) convergence to enable knowledge sharing, the latter aspiration demands an even closer integration of the partners; foremost backed by extended stays of key personnel (e.g., secondment) to enable learning-by-doing, imitation and observation.

10.2 Implications for Theory

The thesis has tied in with an emerging discussion within innovation research suggesting a multiplicity of forms of distance, respectively proximity, underpinning interactive learning and novelty generation (Chapter 4). To substantiate the debate, different theoretical lines have been fused: based on central theories which provide rationales for and characterise inter-organisational co-operation, in particular interactive learning and novelty generation in projects (Chapter 2), the argument has turned to a process perspective centring on knowledge sharing between organisations and its key preconditions; i.e., the ability and motivation to share knowledge (Chapter 3). Together, the thesis has drawn on multiple theoretical perspectives – innovation research, co-operation research, knowledge management and sociology of knowledge – and thus yields insights for various directions.

In the prospect of increasingly organisationally and globally distributed innovation activities, **innovation researchers** recently question the impact of geographic proximity for interactive learning and novelty generation. Instead, they postulate a multiplicity of forms of proximity of a more socio-economic nature, which underpin and shape these processes. In this canon, geographic proximity is thought to have an indirect, supportive function, primarily to strengthen other forms of proximity or mediate the effects of other forms of distance. This emerging line of research – which is most prominently forwarded by the 'French School of Proximity Dynamics' or 'Proximity Economics' group – is currently in a conceptual stage, with many different taxonomies, labels and interpretations. Thus, the conceptual clarity which is initially envisaged currently risks being diluted again and empirical evidence to substantiate the argument and elucidate the relative weight and interplay of different dimensions of distance is claimed.

This thesis has contributed to fill this gap. Based on existing taxonomies, a conceptual framework has been developed, theoretically discussed and empirically tested. Theoretically, the argument has centrally built on insights from knowledge sharing and discussed the different dimensions of distance in the light of their influence on the ability and motivation of the partners to share knowledge. Empirically, the thesis has provided in-depth insight on the (relative) impact and interplay of different forms of distance. Centrally, the findings have corroborated the suggested dominance of socio-economic (or socio-cognitive) forms of proximity that are directly related to knowledge and cognition and the rather indirect impact of geographic proximity. Technological and institutional proximity have turned out to be much more decisive in processes of interactive learning and novelty generation than the geographic locations of the partners. Moreover, it is not 'proximity' which is favourable for learning and novelty generation; by contrast, a requisite level of 'distance' in knowledge and cognition needs to be warranted. This need for distance has lately been introduced into the debate – paraphrased as 'proximity paradox' (Boschma & Frenken, 2009, p. 2) – however, it has not been under empirical scrutiny. Thus, reaching 'beyond the local', in particular in regard to varied knowledge and cognition through technological and institutional distance, is rewarded by higher returns; however, up to a threshold level when the distance in knowledge and cognition exceeds the capacities of the partners to share, combine and integrate each other's knowledge.

In general, biotechnology firms seek globally for complementary resources and new knowledge, largely independent of geographic proximity, but rather bound by a relatively narrow scope in regard to technologies and institutional frameworks. These strategies are supported by virtual proximity and temporary geographic proximity. However, geographic proximity acts as a facilitator of combinations of distant knowledge and cognition, both for identifying opportunities which escape the knowledge and cognitive horizon of a firm as well as for their successful exploitation. Thus, it plays an important indirect role to mediate negative effects of high levels of distance in other dimensions, particularly in regard to technological and organisational distance. Similarly, social networks (relational proximity) can be initiators of international co-operation, but they are not the only sources for international co-operation. It has been revealed that neither geographic proximity as proposed by regional innovation scientists, nor social ties as proposed by social network researchers, determine the emergence of new ties as well as their outcomes in respect to learning and novelty generation. Contrariwise, access to complementary resources is the prime driver for partner selection and the outcome of inter-organisational co-operation.

Most basically, the thesis has drawn on central theories from **co-operation research** explaining inter-organisational co-operation; its rationale, characteristics, benefits and challenges. Concurrently, there exists no single, holistic theory on inter-organisational co-operation. Instead, various strands exist in parallel which have been evaluated in regard to their contribution to explain interactive learning and novelty generation in inter-organisational projects. Three theories – Transaction Cost Economics, Resource based View and a Social Network perspective – have been identified as central and combined. Moreover, a more recent Cognitive Theory of the Firm has been introduced to complement prior theories. Reflecting the contribution of these theories, it is confirmed that – in the absence of a holistic theory – a combination of these different lines is needed to gain a comprehensive picture of inter-organisational co-operation. However, in this dynamic business, partner constellations change frequently and relational risks are mediated by the high specificity of knowledge and high knowledge dynamics. Thus, resource considerations are central: access to external resources, in particular knowledge, provides a key rationale for inter-organisational co-operation and at the same time defines its main challenges; i.e., the sharing, combination and integration of tacit, causally ambiguous and socially complex expert knowledge.

Moreover, concurrent research into success factors for inter-organisational co-operation has been evaluated as rather static, often investigating structures and neglecting a process perspective. It postulates a static analysis of partner 'fit', e.g., strategically, technologically and organisationally that does not come up to explain the dynamics of interactive learning and novelty generation. Hence, the view on different dimensions of distance between the partners that provide novelty value but at the same time entail integration problems, and the possibilities to organise proximity within the co-operation provides a valuable alternative perspective. This alternative perspective turns to the dynamics of interactive learning and novelty generation and explicitly considers changes in parameters over time. Thus, it addresses the process of collaboration in addition to structures. This integration of time has more generally been claimed to be missing in many contemporary investigations in organisational research (Janowicz-Panjaitan et al., 2009; Sydow, 2009). It becomes particularly pressing in highly dynamic markets and also with the increase of transient organisational forms such as projects, which serve to pursue a specific goal with 'limits set as to costs and time' (Sydow et al., 2004, p. 1480, see section 1.4).

Likewise, current contributions in **knowledge management** which underscore knowledge sharing as a delicate process that is contingent on the abilities and motivations of those involved have been confirmed. In particular, the relative ability as defined by the overlap in the scientific and technical knowledge bases of the partners is a strong predictor of the success of knowledge sharing; especially when organisations deliberately engage in knowledge sharing such as in inter-organisational co-operation projects. Moreover, the distinction between basic and specialised knowledge bases and the insight that knowledge sharing functions best when combining distinct specialised knowledge based on shared bodies of basic knowledge, offers a more differentiated insight into inter-organisational knowledge sharing.

10.3 Implications for Practice

To generate innovation, firms are increasingly faced by the need to integrate resources across organisations and regions or countries. In particular small firms that are constrained in resources are faced by the need to access a requisite variety of knowledge to realise new combinations. Thus, the interviewees have expressed their need to constantly explore and exploit opportunities globally and expect this to even increase in the future with rising competition from newly emerging countries. This strategy can be highly rewarding; however, it is also marked by challenges, uncertainties and risks. The theoretical frame that has been developed in this thesis which is tailored to the specifics of interactive learning and novelty generation in inter-organisational projects, together with the empirical findings, provide guidance for practitioners throughout the life cycle of a project; in particular in regard to partner selection and the organisation of the project.

First, a framework has been developed from the literature which constitutes a comprehensive, differentiated taxonomy of different forms of distance that influence interactive learning and novelty generation. Its theoretical discussion and empirical test has identified many aspects which need to be considered within inter-organisational co-operation; in particular in regard to **partner selection**.

Thus, the extensive, cross-case analysis has revealed a strong effect of those dimensions of distance that are directly related to knowledge and cognition: technological and institutional distance. Increasing levels of distance in both yield the most rewarding returns in terms of goal achievement and novelty value; however, beyond a threshold level, the partners face increasing challenges of sharing and integrating distant expert knowledge and having to cope with increasing language and cultural differences. Other dimensions, such as organisational distance, are often bemoaned; however, they are not in any case destructive for interactive learning and novelty generation and often only emerge as critical in the case of dwelling conflict. Moreover, it has been revealed that interaction effects prevail. Thus, a simultaneous consideration of different dimensions is necessary and the individual optimum in one dimension deviates from the global optimum.

It is not realistic that firms determine the optimal level of distance in individual dimensions as well as in their entirety. However, it is important that managers identify the challenges inherent in a project and dynamically respond to them. Thus, when firms aim to explore new fields or access complementary knowledge from external sources by reaching out into different dimensions of distance, the benefits and liabilities have to be known and responded to. The framework should help to sensitise practitioners for the benefits, challenges and risks inherent in a particular inter-organisational co-operation project and thus guide practitioners in their cost-benefit assessment and partnering decisions.

Second, the intensive analysis of selected cases has allowed insight into organisational domains and key measures to **organise proximity** within the project. In particular, three organisational domains through which proximity within the project can be organised have been revealed: competence, governance and relationship. In line with the findings from the extensive empirical analysis, the creation of a requisite level of knowledge redundancy, e.g. through competence matching as well as competence building, has been identified as a necessary prerequisite for inter-organisational co-operation in R&D. Particularly when much of the interaction resorts to ICT, a requisite level of 'common ground' (Olson et al., 2009, p. 7) has to be created. Recognising technological and institutional distance as key challenges for knowledge sharing is an important preliminary step to prepare the team for the challenges ahead.

Yet, this needs to be backed by a requisite level of organisational (e.g., governance structures, inter-organisational routines) and relational proximity (trust, obligation) through investments in governance structures and relationship building. For each organisational domain – competence, governance and relationship – a number of measures has been identified that firms draw on in order to organise a requisite level of proximity within the project (see section 9.5). Being restricted in resources and time, the investments to achieve proximity within a project need to be timely implemented.

Finally, it has been found that firms differ in their learning rationales: some pursue a strategy of learning *from* the partner, while others refer to learning *with* the partner. Yet these different learning rationales are often not explicit within the co-operation project. It has been revealed that the quest to learn from the partner necessitates considerably higher investments in knowledge sharing and absorption, which is best achieved through personnel exchanges/secondment. Thus, practitioners need to be explicit about their motives and invest accordingly.

All in all, the impression has been gained that practitioners are at times driven to realise a certain idea or opportunity, underestimating the challenges on the way. To prevent this, the framework which has been developed in this study combined with the insights on key organisational domains and instruments provides a valuable frame of reference for practitioners.

11 Discussion

This final chapter draws central conclusions from the theoretical discussion and empirical investigation and evaluates their contribution in light of the initial aim set out in section 1.2 (section 11.1). On this bases, the limitations of the current study are critically discussed in section 11.2, which simultaneously defines promising avenues for future research.

11.1 Conclusions and Contribution

This thesis has built on the observation of increasingly open and network-like innovation processes where local and global knowledge and expertise are combined to an increasing extent. It is currently assumed that this trend will continue in the future, allowing organisations of all sizes to participate at the global exploration and exploitation of knowledge and skills. Similarly, Johanson and Vahlne (2009) recently stressed that 'international business network coordination will become an increasingly important phenomenon with strong implications for firm-specific advantage as well as for internationalization' (p. 1426).

Tying in with these claims and considering the characteristic resource constraints of SMEs, the aim of the thesis has been to explore whether and under what constellations 'Global Open Innovation' in the form of international inter-organisational co-operation projects in R&D is a viable option for SMEs to participate directly at the global generation and exploitation of knowledge; or whether there exist 'liabilities of distance' that outweigh the benefits (see section 1.2).

There is no straightforward answer: a number of very successful co-operation projects have demonstrated the benefits that international co-operation projects entail. Moreover, for many firms, this co-operation marked an important step in their business development. However, the benefits are not guaranteed, and there are also constellations where the liabilities of distance in fact outweighed, or at least reduced, the benefits.

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Departing from the assumption of a multiplicity of forms of distance shaping interactive learning and novelty generation, these liabilities are particular retraced to high levels of distance in those dimensions that are directly related to knowledge and cognition; i.e., technological and institutional distance. Hence, within a narrow epistemic community, international knowledge sharing is mostly unproblematic. However, with increasing differences in knowledge and cognition and when fueled by large organisational differences, there can be liabilities of (geographic) distance. In this case, increasing investments are necessary; particularly in learning and teaching. Moreover, the distance between two actors needs to be seen as evolving dynamically. Though inter-organisational projects are particularly timely restricted, there is management leeway to organise proximity within the team; provided one is aware of key constellations and cause-and-effect relationships and pulls the right strings.

Fusing the insights from the extensive and the intensive field studies, a holistic model that combines the insights on the effects of distance and the possibilities to organise proximity is sketched in figure 11.1. Here, the different dimensions of distance are depicted as contextual variables, according to which an adequate organisation which is responsive to the potentials and challenges needs to be designed in order to derive maximum benefit from the project. Moreover, the differences as revealed in regard to the invention stage and the learning rationale need to be considered in the design of the co-operation project. In figure 11.1, dotted lines correspond to a rather indirect or weak impact, while solid lines imply a direct influence. However, figure 11.1 presents a simplistic depiction of the relationships which bereaves much of the complexity revealed in this thesis. In particular, the empirical investigation has identified a number of moderating variables which determine the perceived distance in any dimension as well as its impact. In particular, each dimension is not necessarily neutral or objective, but highly perceptual, based on personal experiences, frames of reference and preferences.

All in all, it has been stated initially that the 'external reality' – increasingly open and increasingly global inter-organisational co-operation in R&D – has outpaced a thorough theoretical entourage (see section 1.1). The recent argument of different forms of distance shaping interactive learning and novelty generation has proven as a valuable framework to explain and understand concurrent phenomena. It has relativised the impact of geographic distance and directed attention to those dimensions that are central determinants of the occurrence and outcomes of inter-organisational co-operation in R&D. As such, the thesis offers an alternative, dynamic, view of

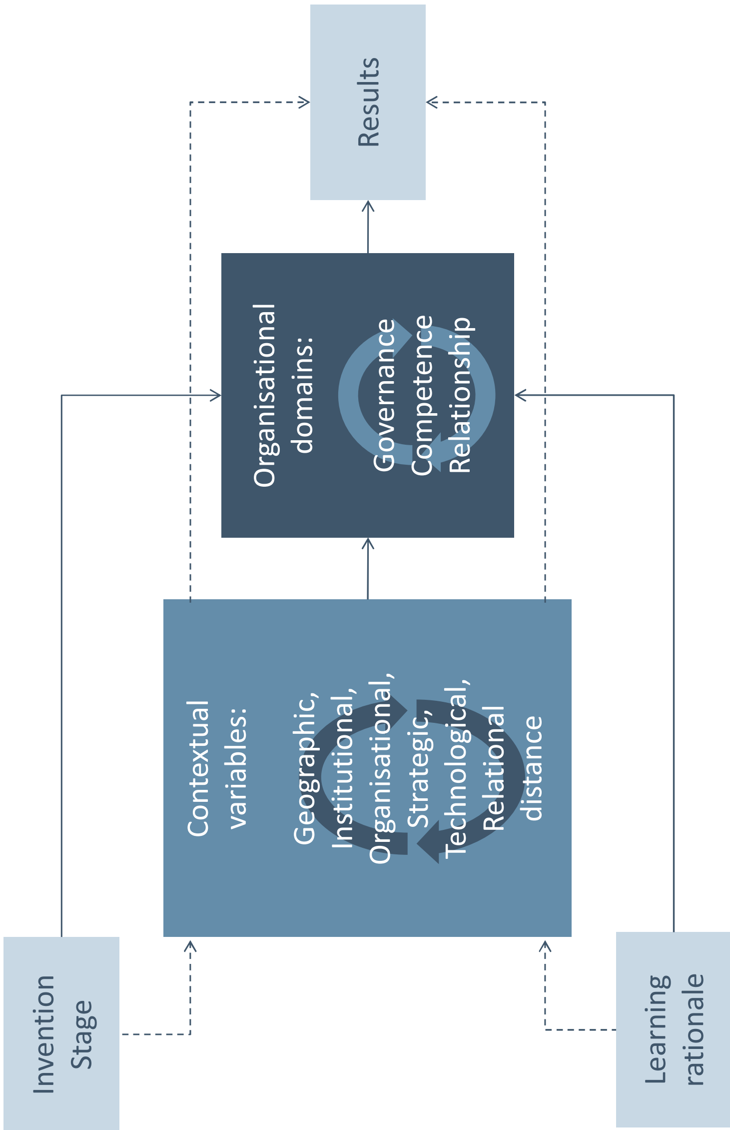

Figure 11.1: A Process Model of Interactive Learning and Novelty Generation

inter-organisational projects which corresponds to the peculiarities of interactive learning and novelty generation within a ‘globalising learning economy’ (Archibugi & Lundvall, 2001).

11.2 Limitations and Avenues for Future Research

While this thesis can be seen as the first contribution which builds on the emerging view of a multiplicity of forms of proximity, respectively distance, and that provides a thorough theoretical and empirical treatise of the argument, there are also some gaps and limitations which offer avenues for future research in this direction.

Theoretically, the notion of different forms of proximity or distance is currently applied to explain interactive learning and novelty generation at different levels of analysis; most notably either from a regional perspective to explore regional dynamics or from an organisational perspective to analyse inter- as well as intra-organisational co-operation. This thesis has adopted an organisational perspective and investigated a particular form of inter-organisational co-operation, namely international projects in R&D. Projects are specifically restrained in time and resources. Thus, their distinct challenges differ from other, long-term, forms of inter-organisational co-operation. Sticking to the organisational perspective, the framework can also be applied to elucidate other forms of inter-organisational co-operation than projects and draw comparisons. Besides, the framework can also be used to investigate intra-firm co-operation, in particular between subsidiaries of MNEs, as well as mergers and acquisitions.[1] Another interesting avenue for future research is to explore the composition of portfolios of co-operation projects and networks. Just as the optimum of distance in any one dimension of distance differs from the global optimum of distance in the co-operation project, so might the global optimum of an entire portfolio of co-operation projects differ from the consideration of just one co-operation project. Thus, the framework can help to design a portfolio of co-operation projects which guarantees the inflow of new ideas and promises to yield novelty but which does not overstrain managerial capacities to handle them.

Conceptually, the thesis pursued a retroductive research approach where emerging

[1] See Makri et al. (2010) or Cloodt et al. (2006) for recent treatises of the meaning of knowledge base relatedness in M&A.

theoretical ideas were combined in an analytic frame which guided the analysis, but which was at the same time open to derive new insights from empirical evidence. This approach provided rich insights beyond the initial suggestions; however, for reasons of generalisability, the framework needs to be tested with a larger sample of projects. Moreover, it has followed a two-step approach, consisting of an extensive, cross-case, and an intensive, case study, part. While the first part aimed to probe and expand the theoretical framework of the impact and interplay of distance in different dimensions, the second part served to explore managerial responses to organise proximity within the project. A case study approach proved necessary to gain in-depth insight in this under-explored area and to include the time aspect. However, in a next step, a full model (as presented in figure 11.1), integrating both the different forms of distance and different managerial responses, can provide interesting insights. This in turn necessitates access to a large sample of cases.

Finally, the empirical part has been reduced to one specific industry in one country. Regarding the industry focus, an industry has been chosen for which the basic observations clearly apply: modern biotechnology is a prototype of an industry which is dominated by SMEs that rely extensively on a division of inventive labour and which combine local resources and expertise with global ones. Biotechnology business is inherently global as it builds on basic principles and laws of nature which apply everywhere around the globe. Moreover, a high transparency of global activities and vast patent protection support global strategies. Nonetheless, even within science-based industries large heterogeneity exists in regard to the key characteristics of R&D activities and the need to access (global) external knowledge.[2] Thus, the transferability of the results to other industries is up for future investigation. Regarding the country focus, a country has been selected that upholds an intermediate position in all characteristic dimensions according to Hofstede's (1980) cultural classification (see section 4.4.2). A different country perspective could lead to shifts in the perception and relative impact of distance in different dimensions. Thus, another direction for future research might be to expand the country scope and compare different countries. Together, the criteria which have been defined in Chapter 6 to guide the selection of the industry and country can support the decision on the selection of future research settings.

[2] For instance, Knorr Cetina (1999) revealed in a detailed comparison of two science-based industries, namely electrophysics and molecular biology, profound differences in the way R&D is conducted in these.

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A Interview Guideline

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Interview Guide

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A General Information

Company Name

Company Contact Details

Name of Interviewee

Position of Interviewee

Interviewee Contact Details

1 Company Overview

Year of Foundation

Number of Employees (FTE)
(End of 2008)

Employee development (2006-2008) ☐ growth ☐ same ☐ decrease

Main Field of Activity

Ownership Structure

2 Company Strategy

2.1 Product-Market Strategy

Business Model	☐ Product Company ☐ Other	☐ Service Company	☐ Technology provider (R&D)
Steps of the value chain internalised	☐ Exploratory Research ☐ Development	☐ Applied Research ☐ Upscaling/ Production	☐ Pre-Clinical Development ☐ Marketing/ Sales
Market Strategy	☐ Big Market ☐ High Quality	☐ Market Niche ☐ Lower Costs	
Main Markets/ Key customers	☐ Local, regional	☐ National	☐ International

2.2 R&D Strategy

R&D expenses as a percentage of the annual expenses/revenues (2007/2008)

☐ ≤ 10 %	☐ > 10 % ; ≤ 20 %	☐ > 20 % ; ≤ 30 %
☐ > 30 % ; ≤ 50 %	☐ > 50 % ; ≤ 75 %	☐ > 75 % ; ≤ 100 %

Approx. how many R&D projects did you pursue during the last five years? (need not be finished)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5-10 ☐ > 10

Goals of R&D activities

☐ New Products	☐ New Processes/ Technologies	☐ Service Innovations
☐ Enhanced Products	☐ Enhanced Processes/ Technologies	☐ Lower Costs
☐ Superior IP	☐ New Knowledge	☐ Organisational Innovations

☐ Others________________

2.3 R&D Co-operation Strategy

A **co-operative project in R&D** is defined as a

- **(temporary) organisational arrangement (project)**
- **between two legally independent parties**
- **where the parties explicitly agree**
- **to combine resources and capabilities in the area of R&D**
- **to achieve a pre-defined goal.**

Organisations involved can be universities, other public research organizations, hospitals, laboratories, governmental agencies; they can involve customers, suppliers, competitors or unrelated organisations.

Pure licensing agreements and contract research or development activities which include no further scientific or technological interaction are excluded.

In approximately how many co-operative projects in R&D were you engaged in during the period 2003 - 2008?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5-10 ☐ > 10

Who were/are the (five most important) partners? Can you rank these in terms of strategic importance?

Partner	Name & Location	Rank
Partner 1		
Partner 2		
Partner 3		
Partner 4		
Partner 5		

Are there different types of partners distinguishable?

What is the importance of international partners for you?

How do you generally proceed to identify and select a suitable partner?

What are generally the prime motives for engaging in a co-operative project in R&D?

Cooperation Motives	Low importance — High importance
Leverage resources & capabilities	
Access complementarities	☐1-☐2-☐3-☐4-☐5
Realise synergies	☐1-☐2-☐3-☐4-☐5
Learn	☐1-☐2-☐3-☐4-☐5
Secure future options	☐1-☐2-☐3-☐4-☐5
Positioning	
Create market standards, dominant designs	☐1-☐2-☐3-☐4-☐5
Shape market structures	☐1-☐2-☐3-☐4-☐5
Enhance legitimacy, reputation	☐1-☐2-☐3-☐4-☐5
Access markets, internationalise	☐1-☐2-☐3-☐4-☐5
Efficiency	
Realise economies of scale, scope	☐1-☐2-☐3-☐4-☐5
Realise economies of time	☐1-☐2-☐3-☐4-☐5
Reduce costs, share risks	☐1-☐2-☐3-☐4-☐5
Flexibility	☐1-☐2-☐3-☐4-☐5
Policy/Others	
Adapt to market or regulatory requirements	☐1-☐2-☐3-☐4-☐5
Leverage supporting regulatory framework	☐1-☐2-☐3-☐4-☐5
Access public funds of home/host government	☐1-☐2-☐3-☐4-☐5
	☐1-☐2-☐3-☐4-☐5

B Case Study Co-operation

For the following, please select **one international co-operative project in R&D** which was either recently completed or which is in an advanced stage where you were involved in the planning, partner-selection, set-up, and execution phase and for which you can assess the success of the co-operation project along various outcome dimensions.

1 General Information

Partner Name

Partner Location

Type of the partner	☐ University ☐ Hospital ☐ Other	☐ Other PRO ☐ NGO	☐ Firm ☐ Regulatory body
Relationship	☐ Competitor ☐ Customer	☐ Supplier ☐ Unrelated	
Size of the partner	☐ Smaller	☐ Same	☐ Larger
Year of establishment			
Length of co-operation	☐ Short-term (<12 months)	☐ Medium-term (12-36 months)	☐ Long-term (>3 years)
Co-operation Scope	☐ Project-based	☐ Task-driven	☐ On-going
Type of co-operation	☐ Financial ☐ Formal/ Contractual	☐ Non-Financial ☐ Informal	☐ Consortia
Content of co-operation	☐ Basic Research ☐ Pre-Clinical Development	☐ Applied Research ☐ Development	
Goals of R&D activities (within the co-operation)	☐ New Products ☐ Enhanced Products ☐ New Processes/ Technologies ☐ Enhanced Processes/ Technologies ☐ Others	☐ Superior IP ☐ Lower Costs ☐ Service Innovations ☐ New knowledge ☐ Organisational Innovations	

2 Co-operation Rationale

2.1 Co-operation Objectives

What were the main objectives of the co-operation project?

Co-operation Objectives		Low importance High importance
1.		☐1-☐2-☐3-☐4-☐5
2.		☐1-☐2-☐3-☐4-☐5
3.		☐1-☐2-☐3-☐4-☐5

2.3 Co-operation Motives

What were the main (strategic) motives for engaging in a co-operative project?

Cooperation Motives	Low importance High importance
Leverage resources & capabilities	
Access complementarities	☐1-☐2-☐3-☐4-☐5
Realise synergies	☐1-☐2-☐3-☐4-☐5
Learn	☐1-☐2-☐3-☐4-☐5
Secure future options	☐1-☐2-☐3-☐4-☐5
Positioning	
Create market standards, dominant designs	☐1-☐2-☐3-☐4-☐5
Shape market structures	☐1-☐2-☐3-☐4-☐5
Enhance legitimacy, reputation	☐1-☐2-☐3-☐4-☐5
Access markets, internationalise	☐1-☐2-☐3-☐4-☐5
Efficiency	
Realise economies of scale, scope	☐1-☐2-☐3-☐4-☐5
Realise economies of time	☐1-☐2-☐3-☐4-☐5
Reduce costs, share risks	☐1-☐2-☐3-☐4-☐5
Flexibility	☐1-☐2-☐3-☐4-☐5
Policy/Others	
Adapt to market or regulatory requirements	☐1-☐2-☐3-☐4-☐5
Leverage supporting regulatory framework	☐1-☐2-☐3-☐4-☐5
Access public funds of home/host government	☐1-☐2-☐3-☐4-☐5
	☐1-☐2-☐3-☐4-☐5

3 Partner Choice

3.1 Formation Process

The co-operation project was initiated by

☐ us ☐ partner ☐ jointly

If you (co-)initiated the co-operation project:

How did you identify this partner?

What were the rationales for selecting this particular partner?

3.2 Relational Characteristics

Please characterise the relationship, your partner and his country in regard to the following dimensions. How do they impact on partner choice and functioning of the co-operation? What can be done to efficiently and effectively bridge the distances incurred?

3.2.1 Geographic Distance	
Absolute geographic distance*	km
Travel time	approx. hours
Time zone difference	approx. hours
Overall assessment of accessibility	Difficult Convenient ☐1-☐2-☐3-☐4-☐5

** to be calculated afterwards*

Open Discussion (importance, impact, key measures):

3.2.2 Institutional Distance	Strongly disagree Strongly agree
The country of the partner differed strongly from Germany in respect to its…	
… regulatory framework	☐1-☐2-☐3-☐4-☐5
… norms, values	☐1-☐2-☐3-☐4-☐5
… culture, habits, attitudes and mentality	☐1-☐2-☐3-☐4-☐5
In some instances we experienced misunderstandings or problems of expressing certain things due to differences in native languages.	☐1-☐2-☐3-☐4-☐5

Open Discussion (importance, impact, key measures):

3.2.3 Organisational Distance	Strongly disagree Strongly agree
The partner's organisation resembled ours in terms of its…	
… basic goals and self-perception (basic logics)	☐1-☐2-☐3-☐4-☐5
… organisational (administrative) structure	☐1-☐2-☐3-☐4-☐5
… mode of operation (work practices, routines, "typical" approach)	☐1-☐2-☐3-☐4-☐5
… organisational culture, commitment and motivation (goals; incentive structures)	☐1-☐2-☐3-☐4-☐5

Open Discussion (importance, impact, key measures):

3.2.4 **Strategic Distance**	Strongly disagree — Strongly agree
At the time of the co-operative project, we were already in a rivalling position with the partner.	☐1-☐2-☐3-☐4-☐5
At the time of the co-operative project, it was likely that the partner could be a future competitor.	☐1-☐2-☐3-☐4-☐5
Our long-term strategic goals were compatible.	☐1-☐2-☐3-☐4-☐5
The partner also engages in co-operative projects with other (potential) competitors (indirect spill-over risk).	☐1-☐2-☐3-☐4-☐5

Open Discussion (importance, impact, key measures):

3.2.5 **Technological Distance**	Strongly disagree — Strongly agree
We shared experience, expertise and thematic understanding due to an overlap/similarities in our …	
… product-market field	☐1-☐2-☐3-☐4-☐5
… methods and techniques	☐1-☐2-☐3-☐4-☐5
… scientific disciplines*	☐1-☐2-☐3-☐4-☐5
Understanding and interpretation was possible due to prior experiences with the field of expertise of the partner.	☐1-☐2-☐3-☐4-☐5

* **Which disciplines are combined on both sides? In what ways do they differ (e.g. different basic approaches to R&D)?**

Open Discussion (importance, impact, key measures):

3.2.6 **Relational Distance**	Strongly disagree — Strongly agree
The relationship with the partner was characterised by high affinity & trust from the beginning due to ...	
… previous business relations with the partner	☐1-☐2-☐3-☐4-☐5
… personnel relations, shared human capital (e.g. former employees, board/VC interlocks)	☐1-☐2-☐3-☐4-☐5
… prior informal personal relations	☐1-☐2-☐3-☐4-☐5
… 3rd party referral	☐1-☐2-☐3-☐4-☐5

Who exactly had prior ties with the partner? (project leader, project team members, adjacent functions)

Open Discussion (importance, impact, key measures):

4 Co-operation Management

4.1 Co-operation Process

Can you please describe the process of the co-operation in more detail?
(Can different stages be identified?)

In what way did the distances as identified before impact on these different stages?

4.2 Co-operation Co-ordination

To which extent did the following mechanisms support this process?

Exchange via	Very rarely — Very frequently
Email	☐1-☐2-☐3-☐4-☐5
Internet/shared databases (group software, chats)	☐1-☐2-☐3-☐4-☐5
Telephone, teleconference	☐1-☐2-☐3-☐4-☐5
Videoconference	☐1-☐2-☐3-☐4-☐5
Face-to-face (project) meetings*	☐1-☐2-☐3-☐4-☐5
(Informal) meetings at other events (e.g. at conferences)	☐1-☐2-☐3-☐4-☐5
On site demonstration*	☐1-☐2-☐3-☐4-☐5
Personnel exchanges, secondments of team members (incl. PhDs)*	☐1-☐2-☐3-☐4-☐5
(Temporary) Co-location of project team*	☐1-☐2-☐3-☐4-☐5

* **How many full day equivalents did you spend together with the partner during one year? (overall?)**
Who participated at personal meetings? (upper echelon, cooperation team members)

5 Co-operation Results

5.1 Contribution of the Co-operation

To what degree were the main objectives achieved within the co-operation project?

Main Objectives	Not achieved / Exceeded expectations
1.	☐1-☐2-☐3-☐4-☐5
2.	☐1-☐2-☐3-☐4-☐5
3.	☐1-☐2-☐3-☐4-☐5

To what degree did the co-operation project contribute to the following?

Success Measures	Not achieved / Exceeded expectations
Inventive, Innovative	
High impact/quality publications	☐1-☐2-☐3-☐4-☐5
New IP	☐1-☐2-☐3-☐4-☐5
Prototypes (e.g. NBE); New/Enhanced products, processes, services	☐1-☐2-☐3-☐4-☐5
Strategic, Technological	
Achievement of strategic goals	☐1-☐2-☐3-☐4-☐5
Achievement of R&D objectives	☐1-☐2-☐3-☐4-☐5
Fulfilment of technical requirements	☐1-☐2-☐3-☐4-☐5
Operational	
Compliance with cooperation budget	☐1-☐2-☐3-☐4-☐5
Compliance with cooperation timelines	☐1-☐2-☐3-☐4-☐5
Cooperation stability	☐1-☐2-☐3-☐4-☐5
Personal	
Satisfaction with partner performance	☐1-☐2-☐3-☐4-☐5
Personally enjoyed working in the alliance	☐1-☐2-☐3-☐4-☐5
Positive learning effect from the cooperation (e.g. routines, pitfalls)	☐1-☐2-☐3-☐4-☐5
Relational	
Development of a trust-based relationship	☐1-☐2-☐3-☐4-☐5
Establishment of a long-term relationship (potential future re-mobilization, JV, M&A)	☐1-☐2-☐3-☐4-☐5
Opened access to other partners	☐1-☐2-☐3-☐4-☐5

Did it live up to full expectations?

5.2 *„Lessons learned“*

Please recapitulate the course of the co-operation project.
What were the most important difficulties experienced in the course of the cooperation?
(any “critical” or “key” situations?)

Reflecting back on the course of the co-operation project, what would have been the most important action/responses to facilitate co-operation?

Are there any further “lessons learned” for future co-operation projects?

B List of Interviewed Firms

J. Hartig, *Learning and Innovation @ a Distance,*
DOI 10.1007/978-3-8349-6904-0,

Table B.1: Registry of Interviewed Rirms

No.	Firm name	Interviewee position
1	AC Immune SA.	CEO
2	Affectis Pharmaceuticals AG	CEO
3	Agenolab GmbH Co. KG	Managing Director/COO
4	Agilent - Biotechnology/ Life Sciences	Project manager
5	Agilent - Control & Automation	Project manager
6	Apogenix GmbH	Vice president business development
7	ATG:biosynthetics	CEO
8	Bicoll GmbH	Managing Director
9	BIOBASE GmbH	CEO
10	BioM – Die BioM Biotech Cluster Development GmbH	Managing Director
11	B·R·A·I·N AG	CEO
12	CellGenix Technologie Transfer GmbH	CEO
13	Coatema – Coating Machinery GmbH -	CEO
14	co.don®AG	CSO
15	Curetis AG	Director assay development
16	DIREVO Industrial Biotechnology GmbH	CEO
17	Entelechon GmbH	Managing Director
18	Epigenomics AG	Senior vice president corporate development
19	Epiontis GmbH	CEO
20	GENEART AG	CEO
21	Genionics AG	CEO
22	IbA GmbH	CEO/CSO

Registry of Interviewed Firms (continued)

No.	**Firm name**	**Interviewee position**
23	IDEA AG	Head of research and clinical development
24	imaGenes GmbH	Managing Director
25	MediGene AG	CEO; project manager
26	Miltenyi Biotec GmbH	Head of R&D
27	MorphoSys AG	Director/Head of alliance management
28	Nycomed Germany Holding GmbH	Early alliance manager
29	PANATecs GmbH	CEO
30	Pharmicell Europe GmbH	Managing Director
31	PLS-Design GmbH	CEO
32	Probiodrug AG	CSO/vice CEO
33	Probiogen AG	CSO
34	ProQinase GmbH	Head of R&D
35	Protagen AG	CEO
36	Qiagen N.V.	Senior scientific director
37	RIEMSER Arzneimittel AG	Director R&D/marketing & sales
38	Sloning BioTechnology GmbH	CEO
39	SYGNIS Pharma AG	Vice president operations
40	Synovo GmbH	CEO
41	TARGOS Molecular Pathology GmbH	CEO
42	TherapySelect GmbH & Co. KG	Managing Director/CSO
43	vasopharm GmbH	Head of business development
44	Warburg–Glycomed GmbH	CEO

C Statistical Annex

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Table C.1: Correlation Analysis: Interdependencies of Independent Variables

	Geographic distance	Institutional distance	Organisational distance	Strategic distance	Technological distance	Relational distance	Firm Age
Geographic distance	1.000						
Institutional distance	0.247	1.000					
Organisational distance	0.013	0.061	1.000				
Strategic distance	-0.054	-0.131	0.279*	1.000			
Technological distance	-0.252	0.178	0.217	-0.110	1.000		
Relational distance	-0.114	-0.204	0.022	0.009	-0.029	1.000	
Firm Age	-0.026	0.016	0.007	0.081	0.313*	-0.146	1.000
Firm Size	0.008	-0.051	0.124	0.232	0.294*	-0.148	0.479***
R&D intensity	0.318*	0.133	0.090	-0.178	-0.086	0.044	-0.599***
R&D breadth	0.154	0.101	-0.064	0.257	0.161	-0.273	0.527***
Network centrality	0.207	0.041	-0.041	0.187	0.064	0.006	0.331**
Duration	0.064	0.153	-0.078	-0.237	0.094	0.123	-0.172
Invention stage	-0.227	-0.036	-0.041	0.048	0.342**	-0.115	0.030
Learning rationale	-0.014	-0.208	-0.020	0.001	-0.060	0.152	-0.245

	Firm size	R&D intensity	R&D breadth	Network Centrality	Duration	Invention stage	Learning rationale
Firm size	1.000						
R&D intensity	-0.459***	1.000					
R&D breadth	0.383**	-0.362**	1.000				
Network Centrality	0.421**	-0.067	0.685***	1.000			
Duration	0.018	0.268	-0.184	0.111	1.000		
Invention stage	-0.050	-0.012	0.375**	0.278	-0.007	1.000	
Co-operation rationale	0.076	0.268	-0.010	0.238	0.199	0.190	1.000

* p<.10, ** p<.05, *** p<.01

Table C.2: The Impact of Distance on Project Outcomes (Tobit Regression, Full Model)

	Goal Achievement		**Inventive Outcome**		**Strategic Outcome**	
	Coef. (Std. err.)	Marginal effect	Coef. (Std. err.)	Marginal effect	Coef. (Std. err.)	Marginal effect
Geogr. dist.	-0.097	-0.0938	-0.180	-0.171	$0.256^{\dagger}$	$0.247^{\dagger}$
	(0.143)	(-0.68)	(0.196)	(-0.92)	(0.129)	(1.99)
Institut. dist.	1.923*	1.853*	2.875	2.727	0.971	0.935
	(0.872)	(2.21)	-1.732	(1.66)	(0.804)	(1.20)
(Institut. dist.)^2	-0.418*	-0.403*	-0.592	-0.561	-0.265	-0.255
	(0.188)	(-2.23)	(0.360)	(-1.65)	(0.169)	(-1.56)
Organisat. dist.	-0.018	-0.0178	0.092	0.0874	0.016	0.0158
	(0.087)	(-0.21)	(0.130)	(0.71)	(0.076)	(0.22)
Strat. dist.	$-0.216^{\dagger}$	$-0.208^{\dagger}$	-0.065	-0.0619	-0.339**	-0.326**
	(0.113)	(-1.90)	(0.161)	(-0.40)	(0.106)	(-3.21)
Technol. dist.	2.123**	2.045**	3.089**	2.930**	2.491***	2.400***
	(0.680)	(3.12)	-1.017	(3.05)	(0.619)	(4.02)
(Technol. dist.)^2	-0.495***	-0.477***	-0.600**	-0.569**	-0.482***	-0.464***
	(0.116)	(-4.26)	(0.167)	(-3.61)	(0.103)	(-4.69)
Relat. dist.	0.382	0.368	-1.181	-1.120	1.892	1.823
	-2.141	(0.18)	-2.913	(-0.41)	-1.942	(0.97)
(Relat. dist.)^2	-0.023	-0.022	0.212	0.201	-0.212	-0.205
	(0.271)	(-0.09)	(0.370)	(0.57)	(0.248)	(-0.85)
Firm Size	0.001*	0.001*	0.001	0.001	0.000	0.000
	(0.000)	(2.13)	(0.001)	(1.66)	(0.000)	(0.11)
Firm Age	0.013	0.0122	0.025	0.024	$-0.046^{\dagger}$	$-0.044^{\dagger}$
	(0.027)	(0.47)	(0.049)	(0.51)	(0.025)	(-1.86)
R&D intensity	0.086	0.0828	0.102	0.0966	-0.137	-0.132
	(0.103)	(0.84)	(0.184)	(0.55)	(0.091)	(-1.50)
R&D breadth	-0.129	-0.124	0.300	0.284	-0.190	-0.183
	(0.128)	(-1.00)	(0.191)	(1.57)	(0.114)	(-1.66)
Network Centr.	-0.123	-0.119	-0.514*	-0.488*	0.388*	0.374*
	(0.153)	(-0.81)	(0.222)	(-2.32)	(0.139)	(2.80)
Duration	-0.234	-0.225	0.325	0.309	-0.604**	-0.572**
	(0.220)	(-1.07)	(0.308)	(1.05)	(0.189)	(-3.26)
Inv. stage	0.533+	$0.514^{\dagger}$	$0.879^{\dagger}$	$0.834^{\dagger}$	0.735*	0.708*
	(0.262)	(2.03)	(0.439)	(1.99)	(0.255)	(2.88)
Learn. rationale	0.189	0.182	0.473	0.448	0.089	0.086
	(0.242)	(0.78)	(0.348)	(1.37)	(0.213)	(0.42)
Constant	-0.005		-2.851		-2.708	
	-4.127		-5.542		-3.704	
Sigma constant	0.499***		0.660***		0.425***	
	(0.065)		(0.094)		(0.058)	
No. of cases	39		37		38	
ll	-26.289		-31.983		-21.024	
Chi^2	43.683		35.672		49.244	
Prob > Chi^2	0.0004		0.0051		0.0001	
R^2_{pseudo}	0.454		0.358		0.539	

† p<.10, * p<.05, ** p<.01, *** p<.001

Table C.3: The impact of distance on project outcomes (Tobit regression, full model), continued

	Operational Outcome		**Personal Outcome**		**Relational Outcome**	
	Coef. (Std. err.)	Marginal effect	Coef. (Std. err.)	Marginal effect	Coef. (Std. err.)	Marginal effect
Geogr. dist.	0.099	0.0977	0.135	0.134	-0.141	-0.141
	(0.175)	(0.56)	(0.100)	(1.36)	(0.135)	(-1.05)
Institut. dist.	0.601	0.595	-0.367	-0.364	2.469**	2.463**
	(0.941)	(0.64)	(0.601)	(-0.61)	(0.809)	(3.05)
(Institut. dist.)^2	-0.152	-0.151	-0.002	-0.002	-0.602**	-0.601**
	(0.200)	(-0.76)	(0.129)	(-0.02)	(0.174)	(-3.45)
Organisat. dist.	-0.050	-0.050	-0.146*	-0.145*	0.133	0.133
	(0.091)	(-0.55)	(0.061)	(-2.39)	(0.083)	(1.62)
Strat. dist.	-0.123	-0.122	0.038	0.0381	-0.137	-0.137
	(0.127)	(-0.97)	(0.078)	(0.49)	(0.109)	(-1.26)
Technol. dist.	1.087	1.076	2.854***	2.837***	2.292**	2.287**
	(0.686)	(1.58)	(0.453)	(6.29)	(0.637)	(3.60)
(Technol. dist.)^2	-0.219†	-0.217†	-0.547***	-0.544***	-0.412**	-0.411**
	(0.115)	(-1.90)	(0.076)	(-7.23)	(0.108)	(-3.82)
Relat. dist.	3.861†	3.823†	-1.217	-1.210	-0.780	-0.778
	-2.099	(1.84)	-1.493	(-0.82)	-1.996	(-0.39)
(Relat. dist.)^2	-0.494†	-0.489†	0.158	0.157	0.053	0.0525
	(0.264)	(-1.87)	(0.190)	(0.83)	(0.253)	(0.21)
Firm Size	0.001	0.001	0.001*	0.001*	0.000	0.000467
	(0.001)	(1.10)	(0.000)	(2.11)	(0.000)	(1.18)
Firm Age	-0.016	-0.0156	-0.051*	-0.0506*	-0.083**	-0.0825**
	(0.027)	(-0.57)	(0.018)	(-2.77)	(0.026)	(-3.24)
R&D intensity	0.092	0.0912	-0.088	-0.0874	-0.021	-0.0211
	(0.111)	(0.83)	(0.071)	(-1.23)	(0.096)	(-0.22)
R&D breadth	-0.043	-0.0422	-0.245*	-0.243*	-0.358**	-0.357**
	(0.131)	(-0.33)	(0.086)	(-2.85)	(0.120)	(-2.98)
Network Centr	0.089	0.0880	0.255*	0.253*	0.398*	0.397*
	(0.162)	(0.55)	(0.105)	(2.44)	(0.143)	(2.78)
Duration	-0.934***	-0.913***	-0.304†	-0.302†	-0.192	-0.192
	(0.209)	(-4.58)	(0.151)	(-2.03)	(0.210)	(-0.92)
Inv. stage	0.754**	0.747**	0.916***	0.911***	0.671*	0.669*
	(0.251)	(3.00)	(0.183)	(5.03)	(0.247)	(2.72)
Learn. rationale	-0.075	-0.0740	-0.082	-0.0812	-0.429†	-0.427†
	(0.225)	(-0.33)	(0.170)	(-0.48)	(0.225)	(-1.91)
Constant	-5.226		4.266		1.336	
	-4.078		-2.881		-3.860	
Sigma constant	0.459***		0.340***		0.468***	
	(0.061)		(0.046)		(0.058)	
No. of cases	37		39		39	
ll	-21.725		-15.125		-22.889	
Chi^2	34.927		64.659		51.379	
Prob > Chi^2	0.0064		0.0000		0.0000	
R^2_{pseudo}	0.446		0.681		0.529	

† p<.10, * p<.05, ** p<.01, *** p<.001